Origins 9

The Omniverse Reloaded…

First off, I want to say thank you to everyone for the encouragement; thanks to you, Im now in the process of turning Origin into a book; each of these entries will be part of their own chapters; I expect to have 30 in all when I'm done, with 3 appendices to help people better understand the mathematics behind string theory and loop quantum cosmology. I will continue to keep my website updated with drafts of every chapter in my my book, as well as updates on the research I am conducting and the work of others. The field is expanding at a rapid rate (we're having our own little inflationary period) so its been fun and exciting to say the least. Chapter 9 will focus on the overall structure of the omniverse and compare its fractal properties to well known states of matter and energy that have been extensibly studied in the lab—this includes superconductors and the properties of absolute zero. I shall present some research at the end of this draft. Following is the temporal structure of the universe: Ordinarily, the idea of backwards time travel would seem to go against established science, but if you scan a new layer with an additional temporal dimension, then backwards time travel becomes easier-- because you're now dealing with two axes and more freedom of movement. There's actually evidence of a second temporal dimension with experiments in meta-materials that are underway (see article at the bottom.) It also shows how higher dimensions and even our familiar dimensions can be reduced to 2D space/time on the holographic boundary of our parent black hole. There's ample evidence showing that's how time works at the quantum level (time symmetry is maintained as time flows both backwards and forwards). It explains quantum nonlocal effects as well as how quantum mechanics influences such varied actions as the future being written in the CMBR through post selection along with the past, photosynthesis, the binding of DNA, how photons of light escape the interior of the sun (post selection as the photons which have escaped come back from the future to select their own escape) and how birds navigate. They're all examples of retro-causation. Bem's study in precognition is also a landmark case. This is actually an example of retro-poly-causality, as precognition allows us a glimpse of one of many different futures. Remember that although the future is dependent on the choices we make concerning the timeline we join, the timelines all have a post selected predetermined outcome that eventually enables them to converge towards the next Big Bang/Bounce-- therefore, although we can pick which timeline we want to join, once there, that timeline decides the outcome. Of course, even making the choice of which timeline to join is currently beyond our technological grasp but there's some glimmers of hope on the horizon (see below.) I have a feeling that precognition has been programmed into our brains through evolution through the ages. When it comes to stuff that involves "survival" we go to extra lengths. Just think of a mother's instinct in protecting her children. Normally, our environment sends conflicting signals but when the survival of ourselves and those we care about is at issue, we can sense quantum nonlocality through ESP. You have to have that "past, present, future" properly all existing simultaneously and thereby put strict constraints on what can be done if you do go back in time. This is where QM is at right no win terms of the "future influencing the present" at least at the quantum level (post selection.) The only other alternative (and one which you might not like) is to have multiple time streams all coexisting (dont think of this as different universes, but more like different pieces of the same universe-- like multiple images of the same thing in a fun house) and going back in time would putyou on a different parallel time stream. I don't buy the MWI idea that parallel time streams get created by human actions, but rather, if it happened, they would have to emerge from a cosmic event near the beginning of the universe, like the inflationary period that followed the big bang/bounce. Inflation by its very nature could cause multiple time lines because the very speed of expansion at faster than light speed could cause emergent time lines which would compartmentalize the universe into different sections. These would still be able to interact with each other in a method similar to what Ryan outlined in virtual pair production and selection (which would eventually result in baby universes forming inside black holes, which a new articleon the existence of exotic matter inside Neutron Stars seems to be hinting at; it sounds like superfluidity and superconductivity exists inside Neutron Stars, which makes you wonder if they hold the secrets to what the early universe might have been like. And neutron stars are a less

extreme case of black holes, imagine what might lie beyond the event horizon, perhaps new universes especially with the linkage of superfluidity and superconductivity with quark-gluon BEC, with multiple event horizons or an event horizon plus a cauchy horizon securing the new universe. There is also the issue of spinning black holes being able to pinch off the interior and creating a new space-time geometry on the inside and new laws of physics with a new holographic boundary and these would be navigable since they have ring singularities (outlining the shape of the universe within and the spinning without, thus both holographic and physical--this is where the funhouse mirror analogy comes in!) and all conservation laws would be maintained. The beauty of this idea is that when expansion of the universe slows down or stops gravity can cause the timelines to converge and finally merge once again right before the next big bang/bounce. In a way, this might account for the "missing mass" dark matter problem we face (dark matter would merely be gravitation from parallel time lines and other universes leaking through), as well as giving the universe enough mass to collapse in time for the next cycle. When these time lines converge back into one we would have the reverse process of inflation (which I called "deflation") because of the added gravitation resulting from time lines collapsing into one. The reason why I think this might work is that in Loop Quantum Cosmology there was a prior universe to this one (or the same universe in a prior cycle) that collapsed.... ok so if it had enough mass to collapse, that mass must still be around somewhere... so I don’t buy all the heat death eternal expansion theories. Having time lines emerge during inflation after big bang/bounce and then converge again during deflation as the universe is collapsing would be the way to do it to have enough mass to have big bounces. BTW there would have to be a quantized discrete number of time lines which could only be reached by traversing that second temporal dimension/layer (think of parallel lines on an X/Y graph) and the shape should resemble a spindle(the structure of the universe as a spindle torus isnt coincidental, it represents how this structure would look as it rotates inside a Kerr Black Hole inside a larger universe with gravity keeping it together), with an emergent point at inflation and a convergent point at deflation with the widest separation occurring when the universe's expansion has stopped and it is getting ready to begin reversal. The universe would be a spindle torus inside a globe (hyper-sphere) -- which would represent the inner holographic boundary of the event horizon of the black hole we're inside and creates the effect of expansion. Note the "hole" in the middle would represent where the universe expanded from initially (big bang) but the "hole" doesn’t widen with time, because there could be a giant black hole there-- thus the universe itself is like a galaxy on a fractally much larger scale. Inside that black hole would be another universe cosmically entangled with ours (the antiverse)and thus as we expand the antiverse collapses and vice versa (through the action of this giant central black hole) with matter and antimatter trading places as they cross the divide (actually it’s a four way entanglement with the antiverse, mirrorverse and antimirrorverse with us and the mirrorverse in sync and the two antis in sync, thus preserving CPT symmetry with two central black holes superimposed like double helix DNA (more proof of fractality and perhaps that the universe/quadverse itself is alive!), just like with some massive galaxies (which probably contain their own quadverses.) As a matter of fact, some of the research I presented indicates that, since everything happens opposite at negative absolute zero temps, that entropy and time itself are reversed thus enabling the once and future collapse without violating any physical laws. In this view, antimatter is only "anti" because it is out of place in our universe and in the previous and next cycles it will be anti to what it is now, with the other members of our quadverse switching places also. Also note that the shape changes depending on perspective. This is to be expected when viewing four dimensional geometry in three dimensions, as our three dimensional senses process the fourth spatial dimension as motion (which might be the source of dark energy and gravitation.) All pasts presents and futures coexist, but we get to chose which time line we follow. Think of each path as a road and while each road has a preselected destination, there area multitude of roads and so a multiple choice of destinations and directions you can go. Precognition can work, but it only shows one possible future out of a multitude.I think the "old fashioned" definition of universe is about as archaic as the big bang (because, like David, I don’t think "universes" exist separately from each other, but are linked through energy transfer-- for example, big flow.) Even if big flow is not proved to occur, there are other signs of energy transfer-- including universal expansion, zero point energy, as well as an elegant way to preserving conservation laws. I agree that there is some sort of limit, (like with alternate timelines) I believe they're emergent from a common layer and new ones aren't created without an input of energy from a "parent" (think black holes from another layer).... which ultimately defines a boundary of physical laws on the outside and a holographic boundary on the inside. I envision it like a cosmic nuclear reaction-- just input a small amount of energy (relatively speaking!) and watch the new universe GO. On the quantum scale, entropy/time isn't a problem (its reversible) so I would envision collapse being able to fuel the next bounce ad infinitum. It actually sounds like trying to sort out how the universe got created without being able to identify the initial boundary conditions. You're basically working from the middle and trying to find your way to the beginning. If it's circular like I think it is, (and works the same way as the absolute zero asymptote does), there should be no beginning or end to the universe, but a "leap" or "skip" across a singularity that doesn't actually exist. A small analogy (and a very hypothetical one) is like the cycle of life (and death), IF we leap over the singularity of death rather than getting stuck within, who knows what lies beyond. Zero and infinity are also asymptotes so this idea of a "leap" across a boundary might work on a number of levels when considering expansion/collapse cycles. My belief is that this analogy works because it preserves all laws of physics because we never reach the singularity stage; as the previous universe collapsed to a certain length before it bounced back and expanded. This is where another dimension of time, like imaginary time, comes into play-- as it runs sideways to our temporal dimension and prevents the singularity even when our time goes to zero. Space doesn't go to zero either, as quantum gravity becomes are pulsive force at distances of around 10 Planck lengths. This would definitely do away with the singularity and explain the large scale structure of the universe. Let's just replace Big Bang with Big Bounce already! This idea of negative absolute zero temperatures also is indicative of yet another balance in the universe in terms of how to reverse entropy and how you get something from nothing which came from another something. Negative dimensions (spatial and temporal) probably work the same way and the antiverse probably exhibits the same kind of reverse behavior to balance ours out. And you can connect all this to Penrose's discoveries in the CMBR which are indicative of a universe before the big bang, like what I was talking about a singularity just being an asymptote in a cyclic universe that jumps from positive space to negative space and back again. Im also including articles on superconductors having been found to contain fractal patterns that determine at what temperature they become superconductive and the link between that and black holes and a really interesting one about absolute zero not really being absolute zero, but being able to create temperatures below that where entropy actually reverses (and the connection between that and how another universe could have existed before the big bang that happens cyclically.)The whole structure of the omniverse feeds back off of each of its fractal scalar parts and forms a vast network, sort of like the behavior of quantum mechanics on an omniversal scale. They are" entangled" in space as well as in time. I think the bidirectional flow of time will also play a role in this and which direction time flows in-- which we would always perceive as forward, even though it might not be relative to another observer in the flip side of our universe (the antiverse) which would be made of an equal amount of antimatter (again, from our perspective.) Which might actually be an explanation for expansion, collapse and why we are seeing galaxies so close to the supposed Big Bang? Expansion/Collapse are just two sides of the same coin. It sounds like a cosmic ring that keeps itself balanced..... cyclic on a vast scale. On the fractal nature of the universe, recent research indicates fractality even extends to mathematics, it shows that fractal doesn’t just exist at the base of the visual universe; it actually exists in the very numbers we use to create a theoretical snapshot of reality. I've always felt that fractals are fundamental to the universe for the very reason that they are the most elegant way to make a large complex structure out of just a few elements. And one thing that we have found true on every level of reality is that the universe likes to accomplish its goals through the path of least resistance (IOW with as little energy expenditure as possible) and fractals are the most efficient way to do this. This holds true for consciousness and the way our brains work also—and hints of this are present in every institution humankind has created, from mathematics and economics to painting and sculpture. I find the connection between black holes and

superconductors highly intriguing, especially since both can be described by the same aspect of string theory (gauge gravity duality).....basically both are fractal in the nature of their charge distributions and the same formula can be used to describe them. Below is something more about the fractal nature of superconductors, a discovery which may eventually lead to higher temp superconductors (perhaps even close to room temp one day) which might also provide the key to generating and triggering wormholes. The fractal scalar nature of the universe can be explained on many levels: 1) inverse fractal nature explains why so much more energy is required to examine the smaller levels 2) it explains the nonlocal properties of quantum mechanics becausethey are derived from string theory 3) the discrete packet nature of reality at the quantum level and 4) properties of the mind which philosophers have identified as qualia which are heretofore unexplainable by classical physics or relativity. I do think that we will be able to explore this realm one day, when technology permits...... technology seems to undergo rapid revolutions and then plateaus with slow evolution until the next sharp revolution (this actually mimics a pattern found in nature-- showing we are connected to the universe on every level) and I believe that with the next revolution we'll be able to explore what we now consider unexplorable. In the quadverse structure of the universe, light exists at the boundary of all four universes and they all have it in common at the luxon wall. We would perceive the antiverse and mirror antiverse as having a reversed arrow of time and being composed of tachyonic superluminal particles, as they would perceive us and the mirrorverse (this could have wonderful implications for generating time machines and interstellar flight if we can bridge their junctures across hyperspace with wormholes-- see below.) Speaking of hyperspace, it and all the higher dimensions exist within our universe in small curled up balls and hyperspace and imaginary time would be like the sea that surrounds them, but if we were to journey outside our universe, they would be much enlarged and we'd see our dimensions as being curled up into balls within hyperspace and imaginary time. Whatever universe you would journey to would have this fractal effect of making all the other dimensions appear very small while its own would be magnified. So we'd have to create a bubble of our own space-time to make this journey (in the case of when we were between universes, in the wormhole), we'd only experience the original dimensions of hyperspace and imaginary time (which is the second dimension of time vital for time travel between parallel timeverses) and so we'd definitely need those bubbles to make the trip. The 2Dstructure of each universe is all you would see "from the outside" as they would all be mobius strips with "the twist" being the central black hole or point of big bang/bounce so you would see all moments of time simultaneously (our universe would appear that way from the outside also)and would just need to jump to the moment of your choice within the timeline of your choice in the universe of your choice (like the conveyor belt I had mentioned, with a twist, literally!) They'd all have their emergent time lines also and the flow of time would actually resemble a mobius strip, a partial CTC, with the twist being the psuedo-singularity asymptotic boundary that is jumped across as a particular component of the quadverse flips from collapse to expansion (death to rebirth.) We might actually need to tap into higher energy universes in order to create a flow effect to make these wormholes stable and journeys possible. Interstellar space and time travel will be a lot easier when humankind develops the technology to develop and control wormholes. Wormholes are the macro version of entanglement and will allow you to jump to different periods of time and space without having to exceed the speed of light. As a matter of fact, an article on time entanglement is included. What you would need to do is generate a strong amount of gravitation around a wormhole to create a closed time like curve. In theory, you should be able to create a macro version of the time entanglement mentioned in the article posted. In the second temporal layer I envisioned, these parallel pasts, presents and futures would all exist together so all you would have to do is "jump" between layers and across time lines by moving across the second temporal dimension and find the conveyor belt you wanted and jump on it at a preselected point (this would represent the point in the past, present or future you want to enter into.) Yes, on the timeline you join time would only go forward, however the act of jumping from one to the other would enable you to join any point on the line-- again, this would require a second temporal dimension which would serve as the background for the parallel conveyor belts, which would represent our time dimension. While each timeline has a post selected predestined future, the myriads of timelines to choose from give a reasonable illusion of free will. For spatial jumps, the worm hole would merely require a macro-quantum entanglement with two separate points in space, which can be accomplished across higher dimensions, in which these two points would be adjacent. Since these dimensions are rolled up into tiny balls, the structure would not have to be large, but it is currently beyond our energy capacity to do either time or space jumping. This should change in the future, however. I agree with this top down approach (but I also like bottom up and think the two together will provide a clearer picture-- like QM and GR.) As a matter of fact, when you consider the whole matter of the "expansion" of space, you realize how ludicrous it is when there are clusters of galaxies on the supposed edge of the universe that shouldn't be there. When one considers the question of what it is the universe is expanding into-- one reaches the inescapable conclusion that it isn't expanding into anything but itself. Thus on a larger scale, our universe might be nothing more than a particle, with its own "inner space" and "inner time" with quantum connections called wormholes (on our scale) connecting everything together. The size of the black hole linking the wormhole would determine its energy level and thus whether it linked two points in the same universe, two points in different time streams or two points in two universes with different laws of physics. Causality itself is just a function of what we perceive and in this higher reality we would see it goes both ways (just like time), just like it does on the quantum level (because we would be looking at it as the quantum level of a higher universe just like our own quantum reality would be the macro reality of a lower energy universe and so on until the whole thing loops back to the original fractally--- thus infinite but contained.) Therefore, there is no speed of light limit, but there is a speed of adjacency limit and what look like two unconnected points in space and/or time can be joined together and thus space travel to distant parts of the universe or time travel to distant parts of the pasts and futures (plural because of the multiple emergent timeline concept nested in additional time like layers, which are as real as space like layers are-- that is, both multiple spatial and temporal dimensions) would be able to be accomplished while still adhering to physical laws. As a matter of fact, research being done at the quantum level is very fruitful in this respect (and on the macro level as well, when modeling black holes with closed time like curves for example, is an example of quantum behavior on the macro scale, which interestingly enough link to worm holes, which are quite like quantum entanglements on the macro scale with their own nested realities just like ours is within another-- scalar and fractal on every level)—and our universe is after all, still a quantum unit on one layer of a multilayered reality along with other quantum units on other layers with different laws of physics (and neighbors on our own also which are the parallel time streams) which each interact with each other to create what we perceive as expansion and contraction on the local level and preserve conservation laws. What we perceive as space and time are merely the aggregates of many interacting layers-- and not even all of them-- as many of them probably are beyond our everyday perceptive abilities at the moment and contribute to the "paranormal."And I hate the Copenhagen Interpretation and am glad it’s on the way out. BTW the reason that increasing precision is increasing the number of solutions is because, with increasing precision, we're discovering more and more layers. The Uncertainty Principle itself is not a "limitation" but abridge to other layers which we shall one day cross (with recent discoveries leading to partial wave reconstruction at the quantum level I think we're on the way there.)Relativity and Quantum Mechanics are two different ways of looking at the same thing, but the reason they are hard to reconcile is because both are only look at small subsections of reality. It's like looking through a telescope. You can focus on what's nearby but what's far away becomes fuzzy-- or you can focus on what's far away and then what's nearby is what becomes fuzzy. We need to think in abstract terms on such a scale that both what's nearby and far away seem the same distance away to bring everything into focus. Paradoxically enough, the best way to do this is to get so far away from your subjects that the distance between them is inconsequential-- then they will both be in focus. Of course there will always be another layer to peel and something will always be a bit fuzzy-- that's how nature works.

I found an interesting connection between this and theories of multiple dimensions. In the articles I have linked below, I can’t help but wonder if by "magic" and "miracle" we are actually referring to multidimensional (or multilayered) existence and our limited perception of only one layer at a time is what limits us in our understanding of consciousness and the cosmos (and how they are inexorably linked to each other.) I also think that Hopf fibrations idea of mapping 4D circles onto single points of space is profound, as it explains how "miracles" would occur (since we only perceive the point, not the whole circle) and also explains how the Casmir effect and the nonlocality of space would occur (note that 4D objects would always appear to be in motion from a 3D perspective.) Further, it can also be extended to include time, and explain things like precognition and retrocausality, as also being part of a circle, whereas time is usually viewed as a simple line. Furthermore, this has huge implications for cosmology, as the fibres of Hopf fibration can be thought of as strings linked together in higher dimensions, detectable as single points to us. The connection to the torus inside the hyper sphere is also noted when trying to view 4Dspace as 3D. I've also found some theories stating that time is just an extension of a fourth spatial dimension that we perceive imperfectly because of the limitations of our five senses. In this case, time could be bidirectional without additional temporal dimensions and just by the full perception of it as a spatial dimension through high energy technology that may become availableto us flatlanders in the future. http://en.wikipedia.org/wiki/Hopf_fibration In the mathematical field of topology, the Hopf fibration (also known as the Hopf bundle or Hopf map) describes a 3-sphere (a hyper sphere in four-dimensional space) in terms of circles and an ordinary sphere. Discovered by Heinz Hopf in 1931, it is an influential early example of a fiber bundle. Technically, Hopf found a many-to-one continuous function (or "map") from the 3-sphereonto the 2-sphere such that each distinct point of the 2-sphere comes from a distinct circle of the3-sphere (Hopf 1931). Thus the 3-sphere is composed of fibers, where each fiber is a circle ・one for each point of the 2-sphere.This fiber bundle structure is denoted where S3 (the 3-sphere) is the total space, S2 (the ordinary 2-sphere) the base space, S1 (a circle) the fiber space, and p: S3→S2 (Hopf's map) the bundle projection. The Hopf fibration, like any fiber bundle, has the important property that it is locally a product space. However it is not a trivial fiber bundle, i.e., S3 is not (globally) a product of S2 and S1. This has many implications: for example the existence of this bundle shows that the higher homotopy groups of spheres are not trivial in general. It also provides a basic example of a principal bundle, by identifying the fiber with the circle group. Stereographic projection of the Hopf fibration induces a remarkable structure on R3, in which space is filled with nested tori made of linking Villarceau circles. Here each fiber projects to a circle in space (one of which is a "circle through infinity" ・ a line). Each torus is the stereographic projection of the inverse image of a circle of latitude of the 2-sphere. (Topologically, a torus is theproduct of two circles.) One of these tori is illustrated by the image of linking key rings on the right. There are numerous generalizations of the Hopf fibration. The unit sphere in Cn+1 fibers naturally over CPn with circles as fibers, and there are also real, quaternionic, and octonionic versions of these fibrations. In particular, the Hopf fibration belongs to a family of four fiber bundles in which the total space, base space, and fiber space are all spheres:

In fact these are the only such fibrations between spheres. The Hopf fibration is important in twistor theory. http://en.wikipedia.org/wiki/Twistor_theory In theoretical and mathematical physics, twistor theory is a mathematical theory mapping the geometric objects of conventional 3+1 space-time (Minkowski space) into geometric objects in a4 dimensional space with metric signature. This space is called twistor space, and its complex valued coordinates are called "twistors."Twistor theory was first proposed by Roger Penrose in 1967, as a possible path to a theory of quantum gravity. The twistor approach is especially natural for solving the equations of motion of massless fields of arbitrary spin. In 2003, Edward Witten proposed to marry twistor and string theory by embedding the topological B model of string theory in twistor space. His objective was to model certain Yang-Mills amplitudes. The resulting model has come to be known as twistor string theory. Twistor theory is unique to 4D Minkowski space and the metric signature, and does not generalize to other dimensions or metric signatures. At the heart of twistor theory lies the isomorphism between the conformal group Spin and SU, which is the group of unitary transformations of determinant 1 over a four dimensional complex vector space. These transformations leave invariant a Hermitian norm of signature.is the real 6D vector space corresponding to the vector representation of Spin is the real 5D projective representation corresponding to the equivalence class of nonzero points in under scalar multiplication. corresponds to the subspace of corresponding to vectors of zero norm. This is conformally compactified Minkowski space is the 4D complex Weyl spinor representation and is called twistor space. It has an invariantHermitian sesquilinear norm of signature is a 3D complex manifold corresponding to projective twistor space is the subspace of corresponding to projective twistors with positive norm (the sign of the norm, but not its absolute value is projectively invariant). This is a 3D complex manifold is the subspace of consisting of null projective twistors (zero norm). This is a real-complex manifold (i.e., it has 5 real dimensions, with four of the real dimensions having a complex structure making them two complex dimensions) is the subspace of projective twistors with negative norm. and are all homogeneous spaces of the conformal group. Additionally it admits a conformal metric (i.e., an equivalence class of metric tensors under Weyl re-scalings) with signature (+++−). Straight null rays map to straight null rays under a conformal transformation and there is a unique canonical isomorphism between null rays in and points in respecting the conformal group. In, it is the case that positive and negative frequency solutions cannot be locally separated. However, this is possible in twistor space. For many years after Penrose's foundational 1967 paper, twistor theory progressed slowly, in part because of mathematical challenges. Twistor theory also seemed unrelated to ideas in mainstream physics. While twistor theory appeared to say something about quantum gravity, its potential contributions to understanding the other fundamental interactions and particle physicswere less obvious. Witten (2003) proposed a connection between string theory and twistor geometry, called twistor string theory. Witten (2004) built on this insight to propose a way to do string theory in twistor space, whose dimensionality is necessarily the same as that of 3+1 Minkowski spacetime. Hence twistor string theory is a possible way to eliminate the need for more than 3 spatial dimensions when doing (super) string theory. Although Witten has said that "I think twistor string theory is something that only partly works," his work has given new life to the twistor research program. For example, twistor string theory may simplify calculating scattering amplitudes from Feynman diagrams. Witten's twistor string theory is defined on the super twistor space . Super twistors are a supersymmetric extension of twistors introduced by Alan Ferber in 1978.[3] Along with the standard twistor degrees of freedom, a super twistor contains N fermionic scalars, where N is the number of supersymmetries. The superconformal algebra can be realized on super twistor space. The fibers of the Hopf fibration stereographically project to a family of Villarceau circles in R3.The Hopf fibration has many implications, some purely attractive, others deeper. For example, stereographic projection of S3 to R3 induces a remarkable structure in R3, which in turn illuminates the topology of the bundle (Lyons 2003). Stereographic projection preserves circles and maps the Hopf fibers to geometrically perfect circles in R3 which fill space. Here there is one exception: the Hopf circle containing the projection point maps to a straight line in R3 ・ a "circle through infinity".The fibers over a circle of latitude on S2 form a torus in S3 (topologically, a torus is the product of two circles) and these project to nested toruses in R3 which also fill space. The individual fibers map to linking Villarceau circles on these tori, with the exception of the circle through the projection point and the one through its opposite point: the former maps to a straight line, the latter to a unit circle perpendicular to, and centered on, this line, which may be viewed as a degenerate torus whose radius has shrunken to zero. Every other fiber image encircles the line as well, and so, by symmetry, each circle is linked through every circle, both in R3 and in S3. Two such linking circles form a Hopf link in R3

Hopf proved that the Hopf map has Hopf invariant 1, and therefore is not null-homotopic. In fact it generates the homotopy group π3(S2) and has infinite order. In quantum mechanics, the Riemann sphere is known as the Bloch sphere, and the Hopf fibration describes the topological structure of a quantum mechanical two-levelsystem or qubit. Similarly, the topology of a pair of entangled two-level systems is given by the Hopf fibration. (Mosseri & Dandoloff 2001). The regular 4-polytopes: 8-cell (Tesseract), 24-cell, and 120-cell, can each be partitioned into disjoint great circle rings of cells forming discrete Hopf fibrations of these polytopes. The Tesseract partitions into two interlocking rings of four cubeseach. The 24-cell partitions into four rings of six octahedrons each. The 120-cellpartitions into twelve rings of ten dodecahedrons each. http://en.wikipedia.org/wiki/Homotopy_groups_of_spheres In the mathematical field of algebraic topology, the homotopy groups of spheres describe how spheres of various dimensions can wrap around each other. They are examples of topological invariants, which reflect, in algebraic terms, the structure of spheres viewed as topological spaces, forgetting about their precise geometry. Unlike homology groups, which are also topological invariants, the homotopy groups are surprisingly complex and difficult to compute. The n-dimensional unit sphere ・ called the n-sphere for brevity, and denoted as Sn・ generalizes the familiar circle (S1) and the ordinary sphere (S2). The n-sphere maybe defined geometrically as the set of points in a Euclidean space of dimension n + 1located at a unit distance from the origin. The i-th homotopy group πi (Sn) summarizes the different ways in which the i-dimensional sphere Si can be mapped continuously into the n-dimensional sphere Sn. This summary does not distinguish between two mappings if one can be continuously deformed to the other; thus, only equivalence classes of mappings are summarized. An "addition" operation defined on these equivalence classes makes the set of equivalence classes into an abelian group.The problem of determining πi (Sn) falls into three regimes, depending on whether i is less than, equal to, or greater than n. For 0 < i < n, any mapping from Si to Sn ishomotopic (i.e., continuously deformable) to a constant mapping, i.e., a mapping thatmaps all of Si to a single point of Sn. When i = n, every map from Sn to itself has a degree that measures how many times the sphere is wrapped around itself. This degree identifies πn (Sn) with the group of integers under addition. For example, every point on a circle can be mapped continuously onto a point of another circle; as the first point is moved around the first circle, the second point may cycle several times around the second circle, depending on the particular mapping. However, the most interesting and surprising results occur when $i > n$. The first such surprise wasthe discovery of a mapping called the Hopf fibration, which wraps the 3-sphere S3

around the usual sphere S2 in a non-trivial fashion, and so is not equivalent to a one-point mapping. The question of computing the homotopy group $\pi_{n+k}(S^n)$ for positive k turned out to be a central question in algebraic topology that has contributed to development of many of its fundamental techniques and has served as a stimulating focus of research. One of the main discoveries is that the homotopy groups $\pi_{n+k}(S^n)$ are independent of n for $n \geq k + 2$. These are called the stable homotopy groups of spheres and have been computed for values of k up to 64. The stable homotopy groups form the coefficient ring of an extraordinary cohomology theory, called stable cohomotopy theory. The unstable homotopy groups (for $n < k + 2$) are more erratic; nevertheless, they have been tabulated for $k < 20$. Most modern computations use spectral sequences, a technique first applied to homotopy groups of spheres by Jean-Pierre Serre. Several important patterns have been established, yet much remains unknown and unexplained. I just had a discussion with Jim Whitescarver, who is an informational physicist, about the topics of fractals, chaos, quantum mechanics and reality; here is a small snippet:

Me: Hasn’t quantum mechanics shown to be behind photosynthesis as well as the binding of DNA? I also read that entanglement has been observed in larger structures closer to the "macro" level. Macro is just a sum of what occurs on the quantum level anyway-- the quantum is "real" the macro is more of an emergent creation built on the pillars of quantum mechanics. The fractal nature of reality, the huge roles that variance and chaos play in everything from biochemical reactions to the way the land, ocean and atmosphere couple in order to create weather and climate are all indicative of a quantum foundation (these same variances are what quantum probabilities are built on.)

Jim: Great points Alex. We do need to be explicit as to what we mean by what is "real" or we wind upin silly argument like those between Heisenberg and Einstein as to whether an electron is real or just a pattern exhibited periodically by quantum logical kinetics. What is real to us it our experience and we do not experience individual quantum events. We experience a stochastic world that averages the effects of gazillions of quantum interactions. We live in a probabilistic realm. As Mead puts it, we are viewing a clear quantum through fuzzy glasses. That fuzzy world is our ordinary reality but most quantum formulations wrongly presume we are viewing a fuzzy quantum with clear glasses. What we can say is that quantum interaction is fundamental and the macro world is statistically emergent. Both worlds are real. What is interesting about the finding that photosynthesis and genetics employ quantum logical interaction, is that it is not at the fundamental level, but at the emergent molecular level.

We find there are macro quantum processes that abstract the underlying fundamental quantum interaction. Chemistry is becoming quantum chemistry, a diverse range of complex systems from turbulence to economics are becoming understood as quantum logical processes that cannot be analyzed any further in legacy fashion. We are finding that all real systems are quantum logical interaction systems on every level of organization that must be analyzed holistically without a preferred context in order to extend our understanding of those systems. But modern physics is a bit schizoid in its recognition of the quantum nature of systems while refusing to abandon its belief that simple classical solutions exist that are complete. They refuse to abandon the impossible notion of a theory of everything that restricts nature to particular algorithms. They refuse to think quantumly. They refuse to accept that the only rule is least actionby delayed choice in the set of all possible algorithms. A consequence of quantum thinking is the realization that thought and things are both manifestations of quantum logical interaction processes without any clear dividing line between the two.

Jim

Me: Thanks Jim-- your enlightened perspective has certainly given some clarity on the issue of quantum vs macro-- the macro is more of an emergent creation built on the pillars of quantum mechanics. The fractal nature of reality, the huge roles that variance and chaos play in everything from biochemical reactions to the way the land, ocean and atmosphere couple in order to create weather and climate are all indicative of a quantum foundation (these same variances are what quantum probabilities are built on.)I've been reading a book called "Black Swan" which hits home as far what you've been sayingabout how quantum mechanics influences so many different areas of our lives—especially economics and finance. The author pays great homage to Mandlebrot for being the father of fractal geometry, which is the epitome of the quantum represented on the macro level. It seems like the rest of the world is slowly awakening to these concepts, as the recent economic crises are seen as an effect of the old, "classical" way of thinking.

Jim: Taleb's "Black Swan" is a great thesis on aspects of quantum thinking, notably, the error of generalization and acceptance of contradictory information from multiple fractally organized contexts. It does exemplify the gaining popularity of such notions in the emerging new sciences. The root of the contradictory nature of quantum logical interaction is that it is implicitly delayed choice least action and at the same time explicitly first opportunity. We need to bend our thinking from different directions finding where the contradictions meet in an overwhelming synthesis. Our nature is to be dogmatic even in our approaches to quantum thinking in spite of great works like those of Carver Mead, Nassim Taleb, Tom Siegfried, Charles Seife, etc. The only ultimate truth is that there is no ultimate truth, and there is always a greater truth. Phys. Rev. Lett. 106, 040403(issue of 28 January 2011) Title and Authors 4 February 2011Time

Travel without Regrets Groundhog Day for particles. A quantum particle can travel around a loop in time and keep returning to the same moment of interaction with another particle without creating any paradoxes, but it must meet strict consistency criteria. Time travel is not ruled out by general relativity, but it might well create problems for the laws of common sense. In the 28 January Physical Review Letters, a team proposes a new way of deciding the possibility or impossibility of quantum states that travel forward and backward in time. The new criterion automatically disallows quantum versions of the "grandfather paradox," in which a person travels back in time and kills her ancestor, thereby ensuring her own demise. The team also performed an experiment that illustrates the paradox-nullifying mechanism. General relativity, Einstein's theory of space and time, allows the existence of closed time-like curves (CTCs)--paths that go forward in time, then back again to reconnect and form closed loops. Although it's unclear whether CTCs can be created, physicists have nevertheless explored their possible consequences, including their influence on quantum mechanics. An ordinary quantum event might involve two particles moving forward in time, changing each other by interacting at some time, then going their separate ways into the future. However, if one outgoing particle enters a CTC, it can double back and become one of the ingoing particles—thus influencing its own transformation. In 1991, Oxford University physicist David Deutsch proposed a consistency condition to avoid time-travel paradoxes: a particle that loops back in time in this way should be in the same quantum state when in reappears in the immediate past of the interaction as it was when it departed the interaction for the immediate future .To see how this condition works, imagine a quantum particle having states labeled 0 and 1. It travels around a CTC and, on its return, interacts with an "external" particle in such a way that 0becomes 1 and 1 becomes 0. Such a particle presents a quantum grandfather paradox: when it comes back around the loop, it flips its former self to the opposite state. However, Deutsch showed that consistency is possible if the particle is in a superposition--a state that is equal parts0 and 1. The interaction exchanges the 0 and the 1, but the state overall remains unchanged. For this to work, the external particle must also be in a superposition that flips back and forth. The paradox is avoided, but a difficulty arises if the external particle is measured. Then it cannot remain in a superposition but must become definitely either 0 or 1--which means that the CTC particle cannot remain in a superposition, either. To preserve consistency, Deutsch argued that the CTC particle must exist in two parallel universes--the "1-universe" and the "0-universe"—and continually switch between them, so that no contradiction occurs in either one. Lorenzo Maccone, of the Massachusetts Institute of Technology and the University of Pavia, Italy, and his colleagues propose a more stringent condition that avoids these difficulties. They require that any measurement of the particle going into the future should yield the same result as measuring it when it returns from the past. So any state that would alter the past when it came around again is disallowed, and no grandfather-type paradoxes can arise. Perhaps surprisingly, "we can still have CTCs even with this strong condition," Maccone says. Only states that avoid paradoxes after the interaction are able to exist beforehand, so the team calls their condition "post-selection."To demonstrate these ideas, the team performed an experiment with photons showing that the consistency condition indeed picks out specific states and destroys all the rest. Lacking an actual CTC to perform the post-selection, the team created photons in a specific quantum state for the input, a state where the polarization was not known or measured but had a correlation with another property, associated with the photon's path. As the photon went through the experiment, it experienced changes that mimicked the 0-to-1 flipping that occurs in the imagined time-travel arrangement. The team found that only those photons that wouldn't lead to paradoxes made it through unscathed. Although the result is in line with expectation, no one has simulated time travel in this way before. An odd consequence of post-selection is that because the presence of a CTC annuls paradoxical states completely, it can disallow some states that seem innocuous today but have unacceptable consequences later. "In principle, one could detect the future existence of time machines by ...looking for deviations now from the predictions of quantum mechanics," says Todd Brun of the University of Southern California in Los Angeles. Although, he adds, it's hard to know in advance what to measure.

http://www.newscientist.com/article/mg20827893.500-how-to-create-temperatures-below-absolute-zero.htmlHow to create temperatures below absolute zero01 December 2010 by David Shiga ABSOLUTE zero sounds like an unbreachable limit beyond which it is impossible to explore. In fact there is a weird realm of negative temperatures that not only exists in theory, but has also proved accessible in practice. An improved way of getting there, outlined last week, could reveal new states of matter. Temperature is defined by how the addition or removal of energy affects the amount of disorder, or entropy, in a system. For systems at familiar, positive temperatures, adding energy increases disorder: heating up an ice crystal makes it melt into a more disordered liquid, for example. Keep removing energy, and you will get closer and closer to zero on the absolute or Kelvin scale (-273.15 °C), where the system's energy and entropy are at a minimum. Negative-temperature systems have the opposite behavior. Adding energy reduces their disorder, and hence their temperature. But they are not cold in the conventional sense that heat will flow into them from systems at positive temperatures. In fact, systems with negative absolute temperatures contain more atoms in high-energy states than is possible even at the hottest positive temperatures, so heat should always flow from them to systems above zero kelvin. Creating negative-temperature systems to see what other "bizarro world" properties they might have is tricky. It is certainly not done by cooling an object down to absolute zero. It is, however, possible to leap straight from positive to negative absolute temperatures. Objects can't be cooled to absolute zero, but you can leap straight to negative temperatures. This has already been done in experiments in which atomic nuclei were placed in a magnetic field, where they act like tiny bar magnets and line up with the field. The field was then suddenly reversed, leaving the nuclei briefly aligned opposite to the direction in which they would have the lowest energy. While they were in this state they fleetingly behaved in a way consistent with them having negative absolute temperatures, before they too flipped over to line up with the field. Because the nuclei can only flip between two possible states - parallel to the field or opposite to it- this set-up offered only limited possibilities for investigation. In 2005 Allard Mosk, now at the University of Twente in the Netherlands, devised a scheme for an experiment that would offer more knobs to turn to explore the negative temperature regime. First, lasers are used to herd the atoms into a tight ball, which is in a highly ordered or low-entropy state. Other lasers are then trained on them to create a matrix of light called an optical lattice, which surrounds the ball of atoms with a series of low-energy "wells". The first set of lasers is then adjusted so that they try to push the ball of atoms apart. This leaves the atoms in an unstable state, as if they were balanced on a mountain peak, poised to roll down hill. The optical lattice acts like a series of crevices along the mountainside, however, halting their progress. In this state, removing some of the atoms' potential energy, letting them roll away from each other, would lead to greater disorder - the very definition of a negative temperature system(see graph). Mosk's ideas have now been refined by Achim Rosch of the University of Cologne, Germany, and colleagues. Their proposed experimental set-up is essentially the same, but Rosch and his team's calculations bolster the case that it is feasible. Crucially, they also suggest a way to test that the experiment would create negative temperatures. Since the atoms in the negative-temperature state have relatively high energies, they should move faster when released from the lattice than would a cloud of atoms with a positive temperature (Physical Review Letters, DOI: 10.1103/PhysRevLett.105.220405)."The new work shows that achieving negative temperatures in this new way in the laboratory is realistic," says Mosk, who was not involved in the new study. "That is something I would be very excited to see."Rosch and his colleagues are theorists, not geared up to perform the experiment, but they think a team of experimentalists could test their proposal within a year or so. Using a combination of lasers and magnetic fields, the atoms in the set-up could be made to attract or repel one another at a range of different strengths. "One can use this to explore and create new states of matter and play with them in regimes we are not used to," says Rosch. This is uncharted territory, he says, and it may hold some surprises. http://focus.aps.org/story/v23/st18

The 1960s TV show The Time Tunnel was science fiction, but in some cases time travel doesn't violate the laws of physics. In fact, it might be used to break a super-secure quantum code, according to a new theory, which illustrates one of the conflicts between quantum mechanics and general relativity. The ability to travel back in time, though entirely hypothetical, isn't explicitly forbidden by our current understanding of space and time, embodied in the general theory of relativity. Time travel tends to play havoc with other laws of physics, however, and in the 29 May Physical Review Letters researchers report another example. They show that data encryption systems relying on quantum principles can be broken by allowing the data stream to interact with a quantum state that travels back in time. This scenario doesn't present an immediate threat to information security, the authors assert. Rather, it's an example of the kind of contradiction that any unified theory of quantum mechanics and gravity will have to resolve. A closed time like curve (CTC) is a looping path that connects back on itself by going forward then backward in time. A CTC might rely on a space-time wormhole, for example, that connects a place and time in the future with another location at some earlier time. Regardless of whether such paths exist, they raise awkward questions, notably the "grandfather paradox" in which a person goes back in time and kills an immediate ancestor. In 1991, David Deutsch of Oxford University in England worked out how to avoid such paradoxes in the case of a quantum particle that travels around a CTC and interacts somewhere along the way with another particle. He proved that it's always possible to find a quantum state that gives the CTC particle a "Groundhog Day existence," in which it cycles around the loop forever, always interacting with the other particle in exactly the same way at the same point in space-time.Todd Brun of the University of Southern California in Los Angeles and his colleagues have now found a way to use states defined by the Deutsch formulation to decode quantum-encrypted messages. Such a message could be sent as a series of particles, each in quantum state "zero," quantum state "one," or a combination state called a superposition. The intended recipient measures each particle but needs additional information after-the-fact from the sender to distinguish the super-positions from the non-superpositions. But a spy who could distinguish "onthe fly" between, say, a zero and a superposition state could intercept the message and also send particles to the recipient that mimic the originals, thereby avoiding detection. For the spy to accomplish this, the researchers imagine a particle entering a CTC so that it travels around and back in time, allowing it to interact with its future self, so to speak, before going on its way again. They describe an interaction that, in the simplest example, leaves a particle in the zero state unchanged but transforms a superposition of zero and one into a pure one state. A standard measurement by the spy that distinguishes one from zero can then reveal with complete certainty whether the initial state was zero or a superposition. Ordinarily such a transformation wouldn't be possible without advanced knowledge of the incoming state. The trick, Brun explains, is that the particle interacts with the transformed version of itself that comes back from the future. Brun says the scheme doesn’t violate any laws of physics, but he admits that the logic is hard to grasp. Compared with regular chronological reasoning, he says, "it's definitely cheating."The researchers go on to show how more complex interactions with a CTC can serve to decipher particles embodying superpositions of any number of states. According to Deutsch, the work

provides support for current theories of quantum information, showing that they can handle even very exotic situations. On the other hand, Brun acknowledges, if you believe quantum mechanics is infallible, you might question Deutsch's 1991 paper, or even the existence of CTCs altogether. Whatever the answer, the difficulties that CTCs cause for quantum mechanics are problems that only a full theory of quantum gravity can resolve, Brun and his colleagues conclude.
http://arstechnica.com/science/news/2011/01/fractals-plus-quantum-mechanics-equals-chaos.ars

Fractals plus quantum mechanics equals chaos By Chris Lee | Last updated 4 days ago Fractals plus quantum mechanics equals chaos Sierpinski Gasket Akkerman has been investigating the properties of light when it is confined to a fractal object. The thing to realize is that this really combines the worst of both worlds: fractals, though visually beautiful, are basically highly abstract mathematics. As such, they are mind-bendingly hard to deal with. Light, on the other hand, is quantum in nature, where the mathematics is not too difficult......Let's say I have a sphere that is constructed from mirrors. Inside that sphere, photons are bouncing back and forth. But, because of the confinement, not all the photons can "fit" into the sphere. Instead, the distance between the walls of the sphere and the wavelength of the photon must be integer multiples of each other・ok, it's actually half the wavelength of light, but work with me here.An easy but not entirely correct way to visualize this is that a photon, starting at the surface of the sphere, will travel across the sphere, bounce off the surface and return to where it started from. When it does so, it will meet up with itself・photons are not point-like objects. If it meets itself inexactly the same phase, called constructive interference (when all the peaks in the wave-like electric field oscillations line up), then the photon fits in the sphere. If it doesn't fit, destructive interference results, and the photon vanishes. So, we can define two volumes: one is the volume of the sphere, and the other is a volumetric representation of the different photons that can fit into the sphere. When working in normal space, these two volumes (one of physical space, the other of photon momentums) coincide. And this coincidence is important, because they are mathematically related to each other, which, with a bit of jiggery pokery, leads to Heisenberg's uncertainty principle. In other words, the fact that we can only jointly know the position and momentum of photon to a certain minimum precision, regardless of the measurement technique, is a consequence of the fact that these two volumes are identical to each other. But what if the interior of the sphere is fractal? Then the physical volume is the same as it was before, but the way that photons travel is not. Indeed, one of the points of a fractal is that starting at a position on the surface and traveling in a direction will never ever take you back to the same position. But that's a dimensionless mathematical thing, while photons are extended objects. So, even though they never come back to exactly the same location, they will still meet up with themselves. When they do, the same rules apply, albeit with the caveat that you never get perfectly constructive or destructive interference. This complicated interior structure ensures that the volumetric representation of the photons that fit on the fractal is different from the volume of the fractal. But the same mathematics apply, so a new "uncertainty" principle can be found. This new uncertainty principle includes the possibility that there is no uncertainty, because the two volumes change semi-independently. Some of you may be thinking, "but a Fourier transform pair is a Fourier transform pair, therefore the uncertainty principle still holds." The world of fractals holds a surprise in store for you. Apparently, you can't do a Fourier transform in a fractal space. This makes sense when you consider that these transforms rely on the existence of a regular series of periodically repeating waves. On a fractal, there are no regular periodic structures that can exist in a self-consistent manner. To put this in more concrete terms, in normal space, doing a Fourier transform followed by undoing it returns you to where you started. On a fractal this is not true. What does this actually mean in terms of the uncertainty principle and real-life objects? No one, not even Akkerman, really knows. The uncertainty principle, apparently, doesn't hold, but this doesn't mean that you can make arbitrarily precise pairs of measurements. Instead, it means we don't know if we can make such measurements.

http://www.wired.com/wiredscience/2010/08/superconductor-fractals/

Inexplicable Superconductor Fractals Hint at Higher Universal Laws By Brandon Keim August 11, 2010

What seemed to be flaws in the structure of a mystery metal may have given physicists a glimpse into as-yet-undiscovered laws of the universe. The qualities of a high-temperature superconductor ・ a compound in which electrons obey the spooky laws of quantum physics, and flow in perfect synchrony, without friction ・ appear linked to the fractal arrangements of seemingly random oxygen atoms. Those atoms weren’t thought to matter, especially not in relation to the behavior of individual electrons, which exist at a scale thousands of times smaller. The findings, published Aug. 12 in Nature, are a physics equivalent of discovering a link between two utterly separate dimensions. “We don’t know the theory for this,” said physicist Antonio Bianconi of Rome’s Sapienza University. “We just make the experimental observation that the two worlds seem to interfere.”......“Everyone was looking at these materials as ordered and homogeneous,” said Bianconi. That is not the case ・ but neither, he found, was the position of oxygen atoms truly random. Instead, they assumed complex geometries, possessing a fractal form: A small part of the pattern resembles a larger part, which in turn resembles a larger part, and so on.“Such Fractals are ubiquitous elsewhere in nature,” wrote Leiden University theoretical physicist Jan Zaanen in an accompanying commentary, but “it comes as a complete surprise that crystal defects can accomplish this feat.”If what Zaanen described as “surprisingly beautiful” patterns were all Bianconi found, the results would have been striking enough? But they appear to have a function. In Bianconi's samples, larger Fractals correlated with higher superconductivity temperatures. When the fractal disappeared at a distance of 180 micrometers, superconductivity appeared at 32degrees Kelvin. When it vanished at 400 micrometers, conductivity went quantum at 42 degrees Kelvin. At -384 degrees Fahrenheit, that's still plenty cold, but it's heading towards the truly high-temperature superconductivity that Bianconi describes as "the dream" of his field, making possible miniature supercomputers that run at everyday temperatures. However, while the arrangement of oxygen atoms appears to influence the quantum behaviors of electrons, neither Bianconi nor Zaanen have any idea how that could be. That fractal arrangements are seen in so many other systems ・ from leaf patterns to stock market fluctuations to the frequency of earthquakes ・ suggests some sort of common underlying laws, but these remain speculative. According to Zaanen, the closest mathematical description of superconductive behavior comes from something called "Anti de Sitter space / Conformal Field Theory correspondence," a subset of string theory that attempts to describe the physics of black holes.http://www.physorg.com/news/2011-02-quantum-mechanics-glass-absolute.htmlResearch uses quantum mechanics to melt glass at absolute zero February 2nd, 2011 in Physics / Quantum Physics Quantum mechanics, developed in the 1920s, has had an enormous impact in explaining how matter works. The elementary particles that make up different forms of matter -- such as electrons, protons, neutrons and photons -- are well understood within the model quantum physics provides. Even now, some 90 years later, new scientific principles in quantum physics are being described. The most recent gives the world a glimpse into the seemingly impossible. Prof. Eran Rabani of Tel Aviv University's School of Chemistry and his colleagues at Columbia University have discovered a new quantum mechanical effect with glass-forming liquids. They've determined that it's possible to melt glass ・ not by heating it, but by cooling it to a temperature near Absolute Zero.

This new basic science research, to be published in Nature Physics, has limited practical application so far, says Prof. Rabani. But knowing why materials behave as they do paves the way for breakthroughs of the future. "The interesting story here," says Prof. Rabani, "is that by quantum effect, we can melt glass by cooling it. Normally, we melt glasses with heat."Turning the thermometer upside-down Classical physics allowed researchers to be certain about the qualities of physical objects. But at the atomic/molecular level, as a result of the duality principle which describes small objects as waves, it's impossible to determine exact molecular position and speed at any given moment ・ a fact known as the "Heisenberg Principle." Based on this principle, Prof. Rabani and his colleagues were able to demonstrate their surprising natural phenomenon with glass. Many different materials on earth, like the silica used in windows, can become a glass — at least in theory ・ if they are cooled fast enough.

But the new research by Prof. Rabani and his colleagues demonstrates that under very special conditions, a few degrees above Absolute Zero (−459.67° Fahrenheit), a glass might melt. It all has to do with how molecules in materials are ordered, Prof. Rabani explains. At some point in the cooling phase, a material can become glass and then liquid if the right conditions exist."We hope that future laboratory experiments will prove our predictions," he says, looking forward to this new basic science paving the way for continued research. Classical glass The research was inspired by Nobel Prize winner Philip W. Anderson, who wrote that the understanding of classical glasses was one of the biggest unsolved problems in condensed matter physics. After the challenge was presented, research teams around the world rose to it. Until now, structural quantum glasses had never been explored ・ that is, what happens when you mix the unique properties in glass and add quantum effects. Prof. Rabani was challenged to ask: if we looked at the quantum level, would we still see the hallmarks of a classical glass? What the researchers unearthed is a new and unique hallmark, showing that quantum glasses have a unique signature. Many materials he says can form a glass if they're cooled fast enough. Even though their theory is not practical for daily use: few individuals own freezers that dip down nearly 500 degrees below zero.

http://www.wired.com/wiredscience/2011/01/timelike-entanglement/

Quantum Entanglement Could Stretch Across Time By Lisa Grossman January 21, 2011

the weird world of quantum physics, two linked particles can share a single fate, even when they're miles apart. Now, two physicists have mathematically described how this spooky effect, called entanglement, could also bind particles across time. If their proposal can be tested, it could help process information in quantum computers and test physicists' basic understanding of the universe.

“You can send your quantum state into the future without traversing the middle time,” said quantum physicist S. Jay Olson of Australia's University of Queensland, lead author of the new study.In ordinary entanglement, two particles (usually electrons or photons) are so intimately bound that they share one quantum state ・ spin, momentum and a host of other variables ・ between them. One particle always “knows” what the other is doing. Make a measurement on one member of an entangled pair, and the other changes immediately. Physicists have figured out how to use Entanglement to encrypt messages in uncrackable codes and build ultrafast computers. Entanglement can also help transmit encyclopedias' worth of information from one place to another using only a few atoms, a protocol called quantum teleportation. In a new paper posted on the physics preprint website arXiv.org, Olson and Queensland colleague Timothy Ralph perform the math to show how these same tricks can send quantum messages not only from place to place, but from the past to the future. The equations involved defy simple mathematical explanation, but are intuitive: If it's impossible to describe one particle without including the other, this logically extends to time as well as space."If you use our time like entanglement, you find that [a quantum message] moves in time, while skipping over the intermediate points," Olson said. "There really is no difference mathematically. Whatever you can do with ordinary entanglement, you should be able to do with time like entanglement."Olson explained them with a Star Trek analogy. In one episode, "beam me up" teleportation expert Scotty is stranded on a distant planet with limited air supply. To survive, Scotty freezes himself in the transporter, awaiting rescue. When the Enterprise arrives decades later, Scotty steps out of the machine without having aged a day."It's not time travel as you would ordinarily think of it, where it's like, poof! You're in the future," Olson said. "But you get to skip the intervening time."

http://discovermagazine.com/2010/apr/01-back-from-the-future

A series of quantum experiments shows that measurements performed in the future can influence the present. Does that mean the universe has a destiny・and the laws of physics pull us inexorably toward our prewritten fate? With Alonso Botero at the University of the Andes in Colombia, Davies has used mathematical modeling to show that bookending the universe with particular initial and final states affects the types of particles created in between. "We've done this for a simplified, one-dimensional universe, and now we plan to move up to three dimensions," Davies says. He and Botero are also searching for signatures that the final state of the universe could retroactively leave on the relic radiation of the Big Bang, which could be picked up by the Planck satellite launched last year.

..... The Rochester experiments seem to demonstrate that actions carried out in the future・in the final, post selection step・ripple back in time to influence and amplify the results measured in the earlier, intermediate step. Does this mean that when the intermediate step is carried out, the future is set and the experimenter has no choice but to perform the later, post selection measurement? It seems not. Even in instances where the final step is abandoned, Tollaksen has found, the intermediate weak measurement remains amplified, though now with no future cause to explain its magnitude at all......DOES THE UNIVERSE HAVE A DESTINY?Is feedback from the future guiding the development of life, the universe, and, well, everything? Paul Davies at Arizona State University in Tempe and his colleagues are investigating whether the universe has a destiny・and if so, whether there is a way to detect its eerie influence. Cosmologists have long been puzzled about why the conditions of our universe・for example, its rate of expansion・provide the ideal breeding ground for galaxies, stars, and planets. If you rolled the dice to create a universe, odds are that you would not get one as handily conducive to life as ours is. Even if you could take life for granted, it's not clear that 14 billion years is enough time for it to evolve by chance. But if the final state of the universe is set and is reaching back in time to influence the early universe, it could amplify the chances of life's emergence. With Alonso Botero at the University of the Andes in Colombia, Davies has used mathematical modeling to show that bookending the universe with particular initial and final states affects the types of particles created in between. "We've done this for a simplified, one-dimensional universe, and now we plan to move up to three dimensions," Davies says. He and Botero are also searching for signatures that the final state of the universe could retroactively leave on the relic radiation of the Big Bang, which could be picked up by the Planck satellite launched last year. Ideally, Davies and Botero hope to find a single cosmic destiny that can explain three major cosmological enigmas. The first mystery is why the expansion of the universe is currently speeding up; the second is why some cosmic rays appear to have energies higher than the bounds of normal physics allow; and the third is how galaxies acquired their magnetic fields. "The goal is to find out whether Mother Nature has been doing her own post selections, causing these unexpected effects to appear," Davies says. Bill Unruh of the University of British Columbia in Vancouver, a leading physicist, is intrigued by Davies's idea. "This could have real implications for whatever the universe was like in its early history," he says.Also see the other articles in this issue's special Beyond Einstein section: Is the Search for Immutable Laws of Nature a Wild-Goose Chase and The Mystery of the Rocketing Particles That Shouldn't Exist.

http://www.nytimes.com/2011/01/06/science/06esp.html?_r=2&hp

Journal's Paper on ESP Expected to Prompt Outrage

By BENEDICT CAREY Published: January 5,

One of psychology's most respected journals has agreed to publish a paper presenting what its author describes as strong evidence for extrasensory perception, the ability to sense future events.Enlarge This Image Heather Ainsworth for The New York Times Work by Daryl J. Bem on extrasensory perception is scheduled to be published this year. When Science Goes Psychic Should scholarly journals publish studies that embrace ESP? The decision may delight believers in so-called paranormal events, but it is already mortifying scientists. Advance copies of the paper, to be published this year in The Journal of Personality and Social Psychology, have circulated widely among psychological researchers in recent weeks and have generated a mixture of amusement and scorn. The paper describes nine unusual lab experiments performed over the past decade by its author, Daryl J. Bem, an emeritus professor at Cornell, testing the ability of college students to accurately sense random events, like whether a computer program will flash a photograph on the left or right side of its screen. The studies include more than 1,000 subjects. Some scientists say the report deserves to be published, in the name of open inquiry; others insist that its acceptance only accentuates fundamental flaws in the evaluation and peer review of research in the social sciences.“It’s craziness, pure craziness. I can’t believe a major journal is allowing this work in,” Ray Hyman, an emeritus professor of psychology at the University Oregon and longtime critic of ESP research, said. “I think it’s just an embarrassment for the entire field.”The editor of the journal, Charles Judd, a psychologist at the University of Colorado, said the paper went through the journal’s regular review process. “Four reviewers made comments on the manuscript,” he said, “and these are very trusted people.”

All four decided that the paper met the journal’s editorial standards, Dr. Judd added, even though “there was no mechanism by which we could understand the results.”But many experts say that is precisely the problem. Claims that defy almost every law of scienceare by definition extraordinary and thus require extraordinary evidence. Neglecting to take this into account ・ as conventional social science analyses do ・ makes many findings look far more significant than they really are, these experts say.“Several top journals publish results only when these appear to support a hypothesis that is counterintuitive or attention-grabbing,” Eric-Jan Wagenmakers, a psychologist at the University of Amsterdam, wrote by e-mail. “But such a hypothesis probably constitutes an extraordinary claim, and it should undergo more scrutiny before it is allowed to enter the field.”Dr. Wagenmakers is co-author of a rebuttal to the ESP paper that is scheduled to appear in the same issue of the journal. In an interview, Dr. Bem, the author of the original paper and one of the most prominent research psychologists of his generation, said he intended each experiment to mimic a well-known classic study, “only time-reversed.”In one classic memory experiment, for example, participants study 48 words and then divide a subset of 24 of them into categories, like food or animal. The act of categorizing reinforces memory, and on subsequent tests people are more likely to remember the words they practiced than those they did not. In his version, Dr. Bem gave 100 college students a memory test before they did the categorizing ・ and found they were significantly more likely to remember words that they practiced later. “The results show that practicing a set of words after the recall test does, in fact, reach back in time to facilitate the recall of those words,” the paper concludes. In another experiment, Dr. Bem had subjects choose which of two curtains on a computer screen hid a photograph; the other curtain hid nothing but a blank screen. A software program randomly posted a picture behind one curtain or the other ・ but only after the participant made a choice. Still, the participants beat chance, by 53 percent to 50 percent, at least when the photos being posted were erotic ones. They did not do better than chance on negative or neutral photos.“What I showed was that unselected subjects could sense the erotic photos,” Dr. Bem said, “but my guess is that if you use more talented people, who are better at this, they could find any of the photos.”Yakir Aharonov's World While his name is relatively well-known in physics world, many outside physics would not know about Yakir Aharanov. Him winning the National Medal of Science in 2010 hopefully will give a bit more publicity to his work, especially the astounding Aharanov-Bohm effect. This brief interview hopefully will provide more insight into him and his work. He certainly has a very progressive idea about how time has the potential to reveal surprises within the QM picture. Q. Based on your work, how should we change our concept of time? A. First let me explain how the idea came about from the properties of quantum mechanics – the suggestion that we should change our notions of time. The basic difference between quantum mechanics and classical physics is that (in quantum physics) two physical systems in exactly the same state, initially, end up later in different state. It means we cannot predict the future exactly. We can only predict probabilities. When I thought about it, it occurred to me that perhaps what nature or quantum mechanics istrying to tell us is, in fact, that there is already a difference between the two particles, but we can discover the difference only later, in the future. Though they're different already, there's no way to find out until you do the experiment in the future, and find the difference between the two systems. That suggested to me that if we are trying to understand how to describe the present time, we need not only information of the past that comes to the present, but also, some information from the future (that) comes back to the present that tells us more information about the system. That is true about microscopic systems in the quantum domain. It suggests perhaps in some future physics, some future theory, we have now an approach to time where the present is described not only by things that happened in the past, (but things that) come back like the movie, Back tothe Future -- come back to affect the present. That's a real change in our understanding of time.

http://physicsandphysicists.blogspot.com/2011/01/yakir-aharonovs-world.html

Fermi's Large Area Telescope sees surprising flares in Crab Nebula

January 6th, 2011 in Space& Earth / Astronomy

Fermi's Large Area Telescope has recently detected two short-duration gamma-ray pulses coming from the Crab Nebula, which was previously believed to emit radiation at very steady rate. The pulses were fueled by the most energetic particles ever traced to a discrete astronomical object. Image courtesy of NASA/ESA.(PhysOrg.com) -- The Crab Nebula, one of our best-known and most stable neighbors in the winter sky, is shocking scientists with a propensity for fireworks・gamma-ray flares set off by the most energetic particles ever traced to a specific astronomical object. The discovery, reported today by scientists working with two orbiting telescopes, is leading researchers to rethink their ideas of how cosmic particles are accelerated."We were dumbfounded," said Roger Blandford, who directs the Kavli Institute for Particle Astrophysics and Cosmology, jointly located at the Department of Energy's SLAC NationalAccelerator

Laboratory and Stanford University. "It's an emblematic object," he said; also knownas M1, the Crab Nebula was the first astronomical object catalogued in 1771 by Charles Messier."It's a big deal historically, and we're making an amazing discovery about it."Blandford was part of a KIPAC team led by scientists Rolf Buehler and Stefan Funk that used observations from the Large Area Telescope, one of two primary instruments aboard NASA's Fermi Gamma-ray Space Telescope, to confirm one flare and discover another. Their report was posted online today in Science Express alongside a report from the Italian orbiting telescope Astro rivelatore Gamma a Immagini L Eggero, or AGILE, which also detected gamma-ray flares in- the Crab Nebula. The Crab Nebula, and the rapidly spinning neutron star that powers it, are the remnants of a supernova explosion documented by Chinese and Middle Eastern astronomers in 1054. After shedding much of its outer gases and dust, the dying star collapsed into a pulsar, a super-dense, rapidly spinning ball of neutrons that emits a pulse of radiation every 33 milliseconds, like clockwork. Though it's only 10 miles across, the amount of energy the pulsar releases is enormous, lighting up the Crab Nebula until it shines 75,000 times more brightly than the sun. Most of this energy is contained in a particle wind of energetic electrons and positrons traveling close to the speed of light. These electrons and positrons interact with magnetic fields and low-energy photons to produce the famous glowing tendrils of dust and gas Messier mistook for a comet over 300 years ago.The particles are even forceful enough to produce the gamma rays the LAT normally observes during its regular surveys of the sky. But those particles did not cause the dramatic flares. Each of the two flares the LAT observed lasted mere days before the Crab Nebula's gamma-ray output returned to more normal levels. According to Funk, the short duration of the flares points to synchrotron radiation, or radiation emitted by electrons accelerating in the magnetic field of the nebula, as the cause. And not just any accelerated electrons: the flares were caused by super-charged electrons of up to 10 peta-electron volts, or 10 trillion electron volts, 1,000 times more energetic than anything the world's most powerful man-made particle accelerator, the Large Hadron Collider in Europe, can produce, and more than 15 orders of magnitude more energetic than photons of visible light."The strength of the gamma-ray flares shows us they were emitted by the highest-energy particles we can associate with any discrete astrophysical object," Funk said. Not only are the electrons surprisingly energetic, added Buehler, but, "the fact that the intensity is varying so rapidly means the acceleration has to happen extremely fast." This challenges current theories about the way cosmic particles are accelerated, which cannot easily account for the extreme energies of the electrons or the speed with which they're accelerated. The discovery of the Crab Nebula's gamma-ray flares raises one obvious question: how can the nebula do that? Obvious question, but no obvious answers. The KIPAC scientists all agree they need a closer look at higher resolutions and in a variety of wavelengths before they can make any definitive statements. The next time the Crab Nebula flares the Fermi LAT team will not be the only team gathering data, but they'll need all the contributions they can get to decipher the nebula's mysteries."We thought we knew the essential ingredients of the Crab Nebula," Funk said, "but that's no longer true. It's still surprising us."Provided by SLAC National Accelerator Laboratory"Fermi's Large Area Telescope sees surprising flares in Crab Nebula." January 6th, 2011.

http://www.physorg.com/news/2011-01-fermi-large-area-telescope-flares.html

New Subatomic Particle Could Help Explain the Mystery of Dark Matter

A flurry of evidence reveals that "sterile neutrinos" are not only real but common, and could bethe stuff of dark matter

By Michael Moyer | January 6, 2011Pulsars, including one inside this "guitar nebula," provide evidence of sterile neutrinos. Image:

Courtesy of Shami Chatterjee and James M. Cordes Cornell University Neutrinos are the most famously shy of particles, zipping through just about everything・your body, Earth, detectors specifically designed to catch them・with nary a peep. But compared with their heretofore hypothetical cousin the sterile neutrino, ordinary neutrinos are veritable firecrackers. Sterile neutrinos don't even interact with ordinary matter via the weak force, the ephemeral hook that connects neutrinos to the everyday world. Recently, however, new experiments have revealed tantalizing evidence that sterile neutrinos are not only real but common. Some of them could even be the stuff of the mysterious dark matter astronomers have puzzled over for decades. Physicists aren't quite ready to make such dramatic pronouncements, but the results "will be extremely important・if they turn out to be correct," says Alexander Kusenko of the University of California, Los Angeles. How did scientists go about looking for particles that are virtually undetectable? Kusenko and Michael Loewenstein of the NASA Goddard Space Flight Center reasoned that if sterile neutrinos really are dark matter, they would occasionally decay into ordinary matter, producing a lighter neutrino and an x-ray photon, and it would make sense to search for these x-rays wherever dark matter is found. Using the Chandra x-ray telescope, they observed a nearby dwarf galaxy thought to be rich in dark matter and found an intriguing bump of x-rays at just the right wavelength. Another piece of evidence comes from supernovae. If sterile neutrinos really do exist, supernovae would shoot them out in a tight stream along magnetic field lines, and the recoil from this blast would kick the pulsars out through the cosmos. It turns out astronomers observe precisely that: pulsars whizzing through the universe at speeds of thousands of kilometers a second .Astronomers don't have to rely on the skies for evidence of sterile neutrinos, though. Scientists at Fermi National Accelerator Laboratory recently verified a 16-year-old experiment that sought the first evidence of these particles. The Fermilab scientists fired ordinary neutrinos through Earth ata detector half a kilometer away. They found that in flight, many of these neutrinos changed their identities in just the way they should if sterile neutrinos do in fact exist. The next step is to confirm the results. Loewenstein and Kusenko recently repeated their experiment on another space-based x-ray telescope, the XMM-Newton, and Fermilab scientists are also setting up another run. The shyest elementary particles may not be able to evade their seekers for long.

http://www.scientificamerican.com/article.cfm?id=a-whole-lot-of-nothing

Neutron star seen forming exotic new state of matter 10:00 04 February 2011 by Rachel Courtland

Spot the superfluid neutron soup

The dense core of a nearby collapsed star is undergoing a rapid chill, providing the first direct evidence that such stars can produce a superfluid of neutrons -- a state of matter that cannot be created in laboratories on Earth. Neutron stars are the remnants of exploded stars. Their cores are so dense that atomic nuclei dissolve, and protons and electrons combine to form a soup dominated by neutrons. If conditions are right, these neutrons ought to be able to pair up to form a superfluid -- a substance with quantum properties that mean it flows with zero friction. Superfluids formed in laboratories can do bizarre things such as creep up the walls of a cup, or remain still even while their container is made to spin.It has long been assumed that neutrons in the cores of neutron stars become superfluid, but without any direct evidence that they do so. That changed in 2010, when astrophysicists Craig Heinke and Wynn Ho examined measurements taken by NASA's orbiting Chandra X-ray Observatory of the 330-year-old neutron star at the heart of the dusty supernova remnant Cassiopeia A. Neutrino release These measurements show the star has dimmed by 20 per cent since it was discovered in 1999,corresponding to an estimated temperature drop of 4 per cent. "It's enormously fast cooling," says Dany Page of the National Autonomous University of Mexico in Mexico City. Now Page and colleagues have calculated that this rapid cooling can be explained if a fraction of the neutrons in the core are undergoing a transition to superfluidity. When neutrons pair up to form a superfluid they release neutrinos which should pass easily through the star, carrying significant amounts of energy with them. This would cause the star to cool rapidly, argue Page's team. A second group that includes Heinke and Ho has also attributed the neutron star's rapid drop in temperature to the onset of neutron superfluidity. Cooling slows Cole Miller of the University of Maryland in College Park finds this reasoning convincing, but points out that both groups of astronomers relied on particularly complex models to estimate the temperature of a star from its brightness, rather than measuring the temperature directly. "Although I would personally bet that these two groups have the correct interpretation, we might not have enough information to say this with certainty," he says.

Astronomers could get firmer evidence for superfluidity by monitoring the neutron star over the coming decades. As a greater fraction of it becomes superfluid, its rate of cooling should slow. There is little chance of creating a soup of superfluid neutrons on Earth. Although particle colliders can create dense fireballs of matter, the temperatures are too high to mimic the interiors of neutron stars. Superfluids made in laboratories are usually composed of chilled helium atoms. Page and his team's conclusions are due to be published in Physical Review Letters, while Heinke, Ho and colleagues will be publishing their work in Monthly Notices of the Royal Astronomical Society:Letters.References: arxiv:1012.0045v2 and arxiv:1011.6142v2

http://www.newscientist.com/article/dn20084-neutron-star-seen-forming-exotic-new-state-of-matter.html

Discovered in Carbon Nanotubes

A new quantum state of water found in carbon nanotubes at room temperature could have important implications for life k fc 01/28/20113

Many astrobiologists think that water is a key ingredient for life. And not just because life on Earth can't manage without it. Water has a weird set of properties that other chemicals simply do not share. One famous example is that water expands when it freezes, ensuring that ice floats rather than sinks. That's important because if it didn't, lakes and oceans would freeze from the bottom upwards, making it hard for complex life to survive and evolve. These and other properties are the result of water molecules' ability to form hydrogen bonds with each other and this gives these molecules some very special properties. Today, George Reiter at the University of Houston and a few buddies put forward evidence that water is stranger than anybody thought. In fact, they go as far as to say that when confined on the nanometre scale, it forms into an entirely new type of quantum water. The background to this is that the electrons in donor and acceptor molecules in hydrogen bonds are indistinguishable, meaning they can travel from one molecule to the next. When the molecules are confined in some way, they can spread some distance, when in a solid for example.

But water molecules can be confined in other ways too. And when that happens, the electronic structure of liquid water becomes a connected network. That raises an important question: how does the behavior of molecules in this electronic network differ from the behavior of molecules in bulk water interacting in an ordinary way? Reiter and co say they have measured the properties of confined in the tiny space inside carbon nanotubes at room temperature and found some important differences. They've done this by filling nanotubes with water and bombarding them with an intense beam of neutrons at the Rutherford Appleton Lab in the UK. The way the neutrons scatter reveals the momentum of the protons inside the nanotubes. It turns out that the protons in this nano-confined water at room temperature behave in an entirely different way to those in bulk water. Protons are known to be sensitive to the electronic fields around them. So when these fields form into unusual electronic networks, it's no surprise the protons behave differently."The departures of the momentum distribution of the protons from that of bulk water are so large, that we believe that the nano-confined water can be properly described as being in a qualitatively different quantum ground state from that of bulk water," they say. They even suggest that there could be some kind of quantum coherence that spreads out through the electronic network. If that's the case, it should be possible to measure how this decoheres in future experiments. That's a big deal. Reiter and co chose carbon nanotubes because they are an analogue of the conditions water faces when passing through living systems, through ion channels in cell membranes, for example. Biologists have long known that flow through these channels is orders of magnitude greater than conventional fluid dynamics predicts. Perhaps this new state of quantum water is the reason why. Reiter and co also say that this quantum water can only exist when it is surrounded by neutral molecules such as the carbon in nanotubes and not in the presence of many commonly studied materials, such as proton exchange membranes like Nafion. This is made of molecules that conduct protons in an entirely different way and so prevents the formation of quantum water. The implication, of course, is that the proton exchange membranes used in everything from chemical production to fuel cells could be dramatically improved by using a neutral carbon-based material. In fact, this phenomenon may be a crucial factor in the very mechanism of life itself. Exciting stuff!

Ref: arxiv.org/abs/1101.4994: Evidence Of A New Quantum State Of Nano-Confifined Water Physicist Discovers How To Make Quantum Foam In A Test Tube Metamaterials should allow scientists recreate and study the properties of space time on the smallest scalekfc 01/26/2011

A metamaterial is stuff that has been engineered to manipulate and steer electromagnetic waves in ways that cannot be reproduced in naturally occurring materials. These materials are periodic structures built out of tiny electronic components such as split-ring capacitors and wires. Individually, these components have a mild interaction with passing em waves. But assembled into a repeating structure, they have a powerful influence on light. There is no shortage of exotic things metamaterials can do: everything from invisibility cloaks to power transmission lines. But one of their most exciting applications is in cosmology because, believe or not, they can mimic the structure of space-time. It turns out that there is a close similarity between the way light is effected by the curvature of space-time and the way it is influenced by the electromagnetic "space" inside a metamaterial. In fact, there is a formal mathematical analogy between these things. So the behavior of photons inside a metamaterial is identical to their behavior in space-time. That's handy because it allows engineers to recreate all kinds of exotic astrophysical objects in the lab. We've already talked about the first black hole made using a metamaterial and seen how it ought to be possible to recreate the Big Bang and even entire multiverses. Now we have another exotic idea. One of the leading thinkers in this area is Igor Smolyaninov at the University of Maryland in College Park. Today, he shows how to create quantum foam inside a metamaterial. First, a quick backgrounder about quantum foam. Nobody is quite sure what laws of physics govern space-time on the smallest scale, that's over the Planck length of about 10^-35 meters. However, our best guess is that quantum mechanics must somehow prevail. And if that's the case then Heisenberg's uncertainty principle must play an important role. This principle implies that to discover anything about a region of space on that scale, we would have to use energies so high that they would create a black hole. (That's why it doesn't make sense to think of anything smaller.)Now, because these black holes can exist, quantum mechanics suggests that they do exist, constantly leaping in and out of existence at the Planck scale. These "virtual black holes" give space-time a certain strange structure at the Planck scale. For want of a better word, physicists call it quantum foam. So what's this got to do with metamaterials? Smolyaninov points out that metamaterials are only transparent for photons of a specific wavelength when their dielectric permittivity is engineered to be below some critical value. Should it rise above this value, the material would suddenly become opaque. So his idea is to create a metamaterial in which the dielectric permittivity is just blow this critical value. Then any thermal fluctuations inside the material ought to raise the permittivity, making the material opaque in that region. So any photons caught in that region will be trapped. "They experience total internal reflection at any incidence angle," says Smolyaninov.That region is therefore an analogue of a black hole. And the fact that these black holes will spring in and out of existence as the temperature naturally fluctuates means that the metamaterial behaves like quantum foam. But the best thing is that this quantum foam effect ought to be straightforward to see.

Smolyaninov says there are well known systems that sit at this critical juncture between transparency and opacity. He points in particular to a mixture of aniline and cyclohexane which is immiscible below 35 degrees C. Above this temperature, however, the liquids happily mix, creating regions with differing permittivity. The interesting effect occurs in the layer between them as they mix, which becomes entirely opaque at the critical temperature. But because of thermal fluctuations, small regions are constantly flickering in and out of opacity, trapping and releasing light in the process. "This behavior is rather similar to the behavior of actual physical space-time on the Planck scale, "says Smolyaninov.In other words, at the critical temperature this stuff is analogous to quantum foam. Smolyninov hasn't actually done this experiment but there's nothing about it that seems particularly tricky. You could do it in an ordinary flask or test tube. In fact, he ends his paper saying: "This effect appears to be large and easy to observe."Which means that sometime soon, physicists will have their own version of quantum foam to playwith in the lab. Ref: arxiv.org/abs/1101.4625 :Virtual Black Holes in Hyperbolic Metamaterials

How to Build A Multiverse Metamaterials allow the creation of adjacent spaces with their own laws of physics, just like themultiverse.kfc 05/10/2010

Metamaterials are substances in which physicists have fiddled with a material's ability to support electric and magnetic fields. They can be designed to steer electromagnetic waves around, over and behind objects to create invisibility cloaks that hide objects. If that sounds a little like the way gravitational fields can bend light, then you won't be surprised to learn that there is a formal mathematical analogy between optical metamaterials and general relativity. The idea that anything Einstein can do, metamaterials can do too has fueled an explosion of interest in "electromagnetic space". Physicists have already investigated black holes that suck light in but won't let it out and wormholes that connect different regions of electromagnetic space. Today, Igor Smolyaninov at the University of Maryland in College Park says that the analogy with space-time can be taken much further. He says it is possible to create metamaterials that are analogous to various kinds of spaces dreamt up by cosmologists to explain aspects of the Universe.In these theories, space can have different numbers of dimensions that become compactified early in the Universe's history, leaving the three dimensions of space and one of time (3+1) that we see today. In symmetries of these spaces depend on the dimensions and the way they are compactified and this in turn determines the laws of physics in these regions. It turns out, says Smolyaninov, that it is possible to create metamaterials with electromagnetic spaces in which some dimensions are compactified. He says it is even possible to create

substances in which the spaces vary from region to region, so a space with 2 ordinary and 2compactified dimensions, could be adjacent to a space with just 2 ordinary dimensions and also connected to a 2d space with 1 compactified dimension and so on. The wormholes that make transitions between these regions would be especially interesting. It ought to be possible to observe the birth of photons in these regions and there is even a sense in which the transition could represent the birth of a new universe."A similar topological transition may have given birth to our own Universe," says Smolyaninov. He goes on to show that these materials can be used to create a multiverse in which different universes have different properties. In fact it ought to be possible create universes in which different laws of physics arise. That opens up a new area for optical devices. Smolyaninov gives the example of electromagnetic universes in which photons behave as if they are massive, massless or charged depending on the topology of space and the laws of physics this gives rise to. Just what kind of devices could exploit this behavior isn't clear yet. If you think of any, post them here. This is clearly a field that for the moment appears to be limited only by the mind of the designer. Ref: arxiv.org/abs/1005.1002: Metamaterial "Multiverse" Recreating the Big Bang Inside Metamaterials

A formal mathematical analogy between the way metamaterials and space-time effect light could allow scientists to recreate Big Bang-type events in the lab.

The analogy between the physics of superfluid helium and general relativity is well known. The mathematics that describe these systems are essentially identical so measuring the properties of one automatically tells you how the other behaves. Now Igor Smolyaninov at the University of Maryland has found another interesting mathematical analogy between optical metamaterials and general relativity. Metamaterials are substances in which the permittivity and permeability have been manipulated in a way that allows fine control over the behavior of light. They have famously been used to create invisibility cloaks that hide objects from view. But Smolyaninov has another idea. Why not create materials that reproduce the behavior of lighting various kinds of space-times. He gives the example of a metamaterial which is a formalequivalent to a (2+2) space-time with two dimensions of space and two of time.His piece de resistance, however, is a mathematical demonstration of an event in which a phase transition inside a (2+2) metamaterial leads to the sudden creation of a 2+1 space-time (two dimensions of space and one of time) together with a large population of particles. Think about that for a moment. What Smolyaninov is describing is an optical analogue of the Big Bang in which a space-time is created along with the particles to populate it. "The characteristic feature of this phase transition appears to be a kind of toy "big bang"," he says.

In principle that's an experiment that could be done in the lab in which you could watch the Big Bang in action.

Ref: arxiv.org/abs/0908.2407: Optical Models of the Big Bang and Non-Trivial Space-Time Metrics Based on Metamaterials

http://www.wired.com/wiredscience/2010/09/stringy-quantum/

String Theory Finally Does Something Useful

By Lisa Grossman September 2, 2010

String theory has finally made a prediction that can be tested with experiments ・ but in a completely unexpected realm of physics. The theory has long been touted as the best hope for a unified “theory of everything,” bringing together the physics of the vanishingly small and the mind bendingly large. But it has also been criticized and even ridiculed for failing to make any predictions that could be checked experimentally. It’s not just that we don’t have big enough particle accelerators or powerful enough computers; string theory's most vocal critics charge that no experiment could even be imagined that would prove it right or wrong, making the whole theory effectively useless. Now, physicists at Imperial College London and Stanford University have found a way to make string theory useful, not for a theory of everything, but for quantum entanglement. "We can use string theory to solve problems in a different area of physics," said theoretical physicist Michael Duff of Imperial College London. "In that context it's actually useful: We can make statements which you could in principle check by experiment." Duff and his colleagues describe their findings in a paper in Physical Review Letters September 2. String theory suggests that matter can be broken down beyond electrons and quarks into tiny loops of vibrating strings. Those strings move and vibrate at different frequencies, giving particles distinctive properties like mass and charge. This strange idea could unite all the fundamental forces, explain the origins of fundamental particles and connect Einstein's general relativity to quantum mechanics. But to do so, the theory requires six extra dimensions of space and time curled up inside the four that we're used to. To understand how these extra dimensions could hide from view, imagine a tightrope walker on a wire between two high buildings. To the tightrope walker, the wire is a one-dimensional line. Butto a colony of ants crawling around the wire, the rope has a second dimension: its thickness. In the same way that the tightrope walker sees one dimension where the ants see two, we could see just three dimensions of space while strings see nine or ten. Unfortunately, there's no way to know if this picture is real. But although string theorists can't test the big idea, they can use this vision of the world to describe natural phenomena like black holes. Four years ago, while listening to a talk at a conference in Tasmania, Duff realized the mathematical description string theorists use for black holes was identical to the mathematical description of certain quantum systems, called quantum bits or qubits. Qubits form the backbone of quantum information theory, which could lead to things like ultrafast computers and absolutely secure communication. Two or more qubits can sometimes be intimately connected in a quantum state called entanglement. When two qubits are entangled, changing one's state influences the state of the other, even when they're physically far apart."As I listened to his talk, I realized the kind of math he was using to describe qubit entanglement was very similar to mathematics I had been using some years before to describe black holes in string theory," Duff said. When he looked into it, the mathematical formulation of three entangled qubits turned out to be exactly the same as the description of a certain class of black holes. In the new study, Duff and his colleagues push the similarity one step further. They used the mathematics of stringy black holes to compute a new way to describe four entangled qubits, an open question in quantum information theory."We made statements that weren't previously known using string theory techniques," Duff said. "Whether the result is some fundamental principle or some quirk of mathematics, we don't know, but it is useful for making statements about quantum entanglement."What's more, these statements are precise and experimentally provable, unlike previous suggestions for ways to test string theory, Duff says.“So in a way, there’s bad news and good news in our paper,” he said. “The bad news is, we’re not describing the theory of everything. The good news is, we’re making a very exact statement which is either right or wrong. There’s no in between.”Duff emphasized that this is only a test of string theory as it relates to quantum entanglement, not as a description of the fundamental physics of the universe. The battle over string theory as a theory of everything rages on.“Already I can imagine enemies sharpening their knives,” Duff said. And they are. A chorus of supporters and critics, including Nobel laureate and string theory skeptic Sheldon Glashow and string theorists John Schwarz of Caltech, James Gates of the University of Maryland, and Juan Maldacena and Edward Witten of the Institute for Advanced Study in Princeton agree that Duff’s argument is “not a way to test string theory” and has nothing to do with a theory of everything. Mathematician Peter Woit of Columbia University, author of the blog Not Even Wrong, think seven claiming that the new paper is a test of quantum entanglement is going too far.“Honestly, I think this is completely outrageous,” he said. Even if the math is the same, he says, testing the quantum entangled system would only tell you how well you understand the math.“The fact that the same mathematical structure appears in a quantum mechanical problem and some model of black holes isn’t even slightly surprising,” he said. “It doesn’t mean that one is a test of the other.”Witten takes a more optimistic view of the theory’s chances, pointing out that the mathematics of string theory have turned out to be coincidentally useful in other areas of physics before. “In general, this kind of work shows that string theory is useful, and in fact by now it has been useful in many different ways,” Witten said in an email to Wired.com.“One might surmise that a physics theory that has proved to be useful in so many different areas of physics and math is probably on the right track,” he added. “But that is another question.”

http://www.wired.com/wiredscience/2010/11/recycled-universe/

Most cosmologists trace the birth of the universe to the Big Bang 13.7 billion years ago. But anew analysis of the relic radiation generated by that explosive event suggests the universe got its start eons earlier and has cycled through myriad episodes of birth and death, with the Big Bangmerely the most recent in a series of starting guns. That startling notion, proposed by theoretical physicist Roger Penrose of the University of Oxfordin England and Vahe Gurzadyan of the Yerevan Physics Institute and Yerevan State University in Armenia, goes against the standard theory of cosmology known as inflation. The researchers base their findings on circular patterns they discovered in the cosmic microwave background, the ubiquitous microwave glow left over from the Big Bang. The circular features indicate that the cosmos itself circles through epochs of endings and beginnings, Penrose and Gurzadyan assert. The researchers describe their controversial findings in an article posted atarXiv.org on November 17.The circular features are regions where tiny temperature variations in the otherwise uniform microwave background are smaller than average. Those features, Penrose said, cannot be explained by the highly successful inflation theory, which posits that the infant cosmos underwent an enormous growth spurt, ballooning from something on the scale of an atom to the size of a grapefruit during the universe's first tiny fraction of a second. Inflation would either erase such patterns or could not easily generate them. "The existence of large-scale coherent features in the microwave background of this form would appear to contradict the inflationary model and would be a very distinctive signature of Penrose's model" of a cyclic universe, comments cosmologist David Spergel of Princeton University. But, he adds, "The paper does not provide enough detail about the analysis to assess the reality of these circles."Penrose interprets the circles as providing a look back, past the glass wall of the most recent Big Bang, into the universe's previous episode, or "aeon," as he calls it. The circles, he suggests, were generated by collisions between super massive black holes that occurred during this earlier aeon. The colliding black holes would have created a cacophony of gravitational waves ・ ripples in space-time due to the acceleration of the giant masses. Those waves would have been spherical and uniformly distributed. According to the detailed mathematics worked out by Penrose, when the uniform distribution of gravitational waves from the previous aeon entered the current aeon, they were converted into a pulse of energy. The pulse provided a uniform kick to the allotment of dark matter, the invisiblematerial that accounts for more than 80 percent of the mass of the cosmos. "The dark matter material along the burst therefore has this uniform character," says Penrose."This is what is seen as a circle in our cosmic microwave background sky, and it should look like a fairly uniform circle." Each circle has a lower-than-average variation in temperature, which is just what he and Gurzadyan found when they analyzed data from NASA's orbiting Wilkinson Microwave Anisotropy Probe, or WMAP, which scanned the entire sky for nine years, and the balloon-borne BOOMERANG experiment, which studied microwave background over a smaller fraction of the heavens. Because the team found similar circular features with two different detectors, Penrose says it's unlikely he and his colleagues are being fooled by instrumental noise or other artifacts. But Spergel says he is concerned that the team has not accounted for variations in the noise level of WMAP data acquired over different parts of the sky. WMAP examined different sky regions for different amounts of time. Maps of the microwave background generated from those regions studied the longest would have lower noise and smaller recorded variations in the temperature of the microwave glow. Those lower-noise maps could artificially produce the circles that Penrose and Gurzadyan ascribe to their model of a cyclic universe, Spergel says. A new, more detailed map of the cosmic microwave background, now being conducted by the European Space Agency's Planck mission, could provide a more definitive test of the theory, Penrose says.

http://www.wired.com/wiredscience/2010/02/what-is-time/

SAN DIEGO ・ One way to get noticed as a scientist is to tackle a really difficult problem. Physicist Sean Carroll has become a bit of a rock star in geek circles by attempting to answer an age-old question no scientist has been able to fully explain: What is time? Sean Carroll is a theoretical physicist at Caltech where he focuses on theories of cosmology, field theory and gravitation by studying the evolution of the universe. Carroll's latest book, From Eternity to Here: The Quest for the Ultimate Theory of Time, is an attempt to bring his theory of time and the universe to physicists and non-physicists alike. Here at the annual meeting of the American Association for the Advancement of Science, where he gave a presentation on the arrow of time, scientists stopped him in the hallway to tell him what big fans they were of his work. Carroll sat down with Wired.com on Feb. 19 at AAAS to explain his theories and why Marty McFly's adventure could never exist in the real world, where time only goes forward and never back.

Wired.com: Can you explain your theory of time in layman's terms?

Sean Carroll: I'm trying to understand how time works. And that's a huge question that has lots of different aspects to it. A lot of them go back to Einstein and space-time and how we measure time using clocks. But the particular aspect of time that I'm interested in is the arrow of time: the fact that the past is different from the future. We remember the past but we don't remember the future. There are irreversible processes. There are things that happen, like you turn an egg into an omelet, but you can't turn an omelet into an egg. And we sort of understand that halfway. The arrow of time is based on ideas that go back to Ludwig Boltzmann, an Austrian physicist in the 1870s. He figured out this thing called entropy. Entropy is just a measure of how disorderly things are. And it tends to grow. That's the second law of thermodynamics: Entropy goes up with time, things become more disorderly. So, if you neatly stack papers on your desk, and you walk away, you're not surprised they turn into a mess. You'd be very surprised if a mess turned into neatly stacked papers. That's entropy and the arrow of time. Entropy goes up as it becomes messier.

So, Boltzmann understood that and he explained how entropy is related to the arrow of time. But there's a missing piece to his explanation, which is, why was the entropy ever low to begin with? Why were the papers neatly stacked in the universe? Basically, our observable universe begins around 13.7 billion years ago in a state of exquisite order, exquisitely low entropy. It's like the universe is a wind-up toy that has been sort of puttering along for the last 13.7 billion years and will eventually wind down to nothing. But why was it ever wound up in the first place? Why was it in such a weird low-entropy unusual state? That is what I'm trying to tackle. I'm trying to understand cosmology, why the Big Bang had the properties it did. And it's interesting to think that connects directly to our kitchens and how we can make eggs, how we can remember one direction of time, why causes precede effects, why we are born young and grow older. It's all because of entropy increasing. It's all because of conditions of the Big Bang.Wired.com: So the Big Bang starts it all. But you theorize that there's something before the Big Bang. Something that makes it happen. What's that? Carroll: If you find an egg in your refrigerator, you're not surprised. You don't say, "Wow, that's a low-entropy configuration. That's unusual," because you know that the egg is not alone in the universe. It came out of a chicken, which is part of a farm, which is part of the biosphere, etc., etc. But with the universe, we don't have that appeal to make. We can't say that the universe is part of something else. But that's exactly what I'm saying. I'm fitting in with a line of thought in modern cosmology that says that the observable universe is not all there is. It's part of a bigger multiverse. The Big Bang was not the beginning. And if that's true, it changes the question you're trying to ask. It's not, "Why did the universe begin with low entropy?" It's, "Why did part of the universe go through a phase with low entropy?" And that might be easier to answer.Wired.com: In this multiverse theory, you have a static universe in the middle. From that, smaller universes pop off and travel in different directions, or arrows of time. So does that mean that the universe at the center has no time? Carroll: So that's a distinction that is worth drawing. There are different moments in the history of the universe and time tells you which moment you're talking about. And then there's the arrow of time, which give us the feeling of progress, the feeling of flowing or moving through time. So that static universe in the middle has time as a coordinate but there's no arrow of time. There's no future versus past, everything is equal to each other.Wired.com: So it's a time that we don't understand and can't perceive? Carroll: We can measure it, but you wouldn't feel it. You wouldn't experience it. Because objects like us wouldn't exist in that environment. Because we depend on the arrow of time just for our existence.Wired.com: So then, what is time in that universe? Carroll: Even in empty space, time and space still exist. Physicists have no problem answering the question of "If a tree falls in the woods and no one's there to hear it, does it make a sound?"They say, "Yes! Of course it makes a sound!" Likewise, if time flows without entropy and there's no one there to experience it, is there still time? Yes. There's still time. It's still part of the fundamental laws of nature even in that part of the universe. It's just that events that happen in that empty universe don't have causality, don't have memory, don't have progress and don't have aging or metabolism or anything like that. It's just random fluctuations.

Wired.com: So if this universe in the middle is just sitting and nothing's happening there, then how exactly are these universes with arrows of time popping off of it? Because that seems like a measurable event. Carroll: Right. That's an excellent point. And the answer is, almost nothing happens there. So the whole point of this idea that I'm trying to develop is that the answer to the question, "Why do we see the universe around us changing?" is that there is no way for the universe to truly be static once and for all. There is no state the universe could be in that would just stay put forever and ever and ever. If there were, we should settle into that state and sit there forever. It's like a ball rolling down the hill, but there's no bottom to the hill. The ball will always be rolling both in the future and in the past. So, that center part is locally static ・ that little region there where there seems to be nothing happening. But, according to quantum mechanics, things can happen occasionally. Things can fluctuate into existence. There's a probability of change occurring. So, what I'm thinking of is the universe is kind of like an atomic nucleus. It's not completely stable. It has a half-life. It will decay. If you look at it, it looks perfectly stable, there's nothing happening… there's nothing happening … and then, boom! Suddenly there's an alpha particle coming out of it, except the alpha particle is another universe.Wired.com: So inside those new universes, which move forward with the arrow of time, there are places where the laws of physics are different ・ anomalies in space-time. Does the arrow of time still exist there? Carroll: It could. The weird thing about the arrow of time is that it's not to be found in the underlying laws of physics. It's not there. So it's a feature of the universe we see, but not a feature of the laws of the individual particles. So the arrow of time is built on top of whatever local laws of physics apply.Wired.com: So if the arrow of time is based on our consciousness and our ability to perceive it, then do people like you who understand it more fully experience time differently than the rest of us? Carroll: Not really. The way it works is that the perception comes first and then the understanding comes later. So the understanding doesn't change the perception, it just helps you put that perception into a wider context. It's a famous quote that's in my book from St. Augustine, where he says something along the lines of, "I know what time is until you ask me for a definition about it, and then I can't give it to you." So I think we all perceive the passage of time in very similar ways. But then trying to understand it doesn't change our perceptions.Wired.com: So what happens to the arrow in places like a black hole or at high speeds where our perception of it changes? Carroll: This goes back to relativity and Einstein. For anyone moving through space-time, them and the clocks they bring along with them – including their biological clocks like their heart and their mental perceptions – no one ever feels time to be passing more quickly or more slowly. Or, at least, if you have accurate clocks with you, your clock always ticks one second per second. That's true if you're inside a black hole, here on Earth, in the middle of nowhere, it doesn't matter. But what Einstein tells us is that path you take through space and time can dramatically affect the time that you feel elapsing. The arrow of time is about a direction, but it's not about a speed. The important thing is that there's a consistent direction. That everywhere through space and time, this is the past and this is the future.

Wired.com: So you would tell Michael J. Fox that it's impossible for him to go back to the past and save his family? Carroll: The simplest way out of the puzzle of time travel is to say that it can't be done. That's very likely the right answer. However, we don't know for sure. We're not absolutely proving that it can't be done.Wired.com: At the very least, you can't go back. Carroll: Yeah, no. You can easily go to the future, that's not a problem.Wired.com: We're going there right now! Carroll: Yesterday, I went to the future and here I am! One of things I point out in the book is that if we do imagine that it was possible, hypothetically, to go into the past, all the paradoxes that tend to arise are ultimately traced to the fact that you can't define a consistent arrow of time if you can go into the past. Because what you think of as your future is in the universe's past. So it can't be one in the same everywhere. And that's not incompatible with the laws of physics, but it's very incompatible with our everyday experience, where we can make choices that affect the future, but we cannot make choices that affect thepast.Wired.com: So, one part of the multiverse theory is that eventually our own universe will become empty and static. Does that mean we'll eventually pop out another universe of our own? Carroll: The arrow of time doesn't move forward forever. There's a phase in the history of the universe where you go from low entropy to high entropy. But then once you reach the locally maximum entropy you can get to, there's no more arrow of time. It's just like this room. If you take all the air in this room and put it in the corner, that's low entropy. And then you let it go and it eventually fills the room and then it stops. And then the air's not doing anything. In that time when it's changing, there's an arrow of time, but once you reach equilibrium, then the arrow ceases to exist. And then, in theory, new universes pop off.Wired.com: So there's an infinite number of universes behind us and an infinite number of universes coming ahead of us. Does that mean we can go forward to visit those universes ahead of us? Carroll: I suspect not, but I don't know. In fact, I have a post doc at Caltech who's very interested in the possibility of universes bumping into each other. Now, we call them universes. But really, to be honest, they are regions of space with different local conditions. It's not like they're metaphysically distinct from each other. They're just far away. It's possible that you could imagine universes bumping into each other and leaving traces, observable effects. It's also possible that that's not going to happen. That if they're there, there's not going to be any sign of them there. If that's true, the only way this picture makes sense is if you think of the multiverse not as a theory, but as a prediction of a theory. If you think you understand the rules of gravity and quantum mechanics really, really well, you can say, "According to the rules, universes pop into existence. Even if I can't observe them, that'sa prediction of my theory, and I've tested that theory using other methods." We're not even there yet. We don't know how to have a good theory, and we don't know how to test it. But the project that one envisions is coming up with a good theory in quantum gravity, testing it here in our universe, and then taking the predictions seriously for things we don't observe elsewhere.

http://www.wired.com/wiredscience/2010/07/time-travel/

Novelists and screenwriters know that time travel can be accomplished in all sorts of ways: A supercharged DeLorean, Hermione's small watch and, most recently, a space-time-bending hot tub have allowed fictional heroes to jump between past and future. But physicists know that time travel is more than just a compelling plot device ・ it's a serious prediction of Einstein's general relativity equations. In a new study posted online July 15, researchers led by Seth Lloyd at MIT analyze how some of the quirks and peculiarities of real-lifetime travel might play out. This particular kind of time travel evades some of its most paradoxical predictions, Lloyd says .Any theory of time travel has to confront the devastating "grandfather paradox," in which a traveler jumps back in time and kills his grandfather, which prevents his own existence, which then prevents the murder in the first place, and so on. One model, put forth in the early 1990s by Oxford physicist David Deutsch, can allow inconsistencies between the past a traveler remembers and the past he experiences. So a person could remember killing his grandfather without ever having done it. "It has some weird features that don't square with what we thought time travel might work out as," Lloyd says. In contrast, Lloyd prefers a model of time travel that explicitly forbids these inconsistencies. This version, posted at arXiv.org, is called a post-selected model. By going back and outlawing any events that would later prove paradoxical in the future, this theory gets rid of the uncomfortable idea that a time traveler could prevent his own existence. "In our version of time travel, paradoxical situations are censored," Lloyd says. But this dictum against paradoxical events causes possible but unlikely events to happen more frequently. "If you make a slight change in the initial conditions, the paradoxical situation won't happen. That looks like a good thing, but what it means is that if you're very near the paradoxical condition, then slight differences will be extremely amplified," says Charles Bennett of IBM's Watson Research Center in Yorktown Heights, New York. For instance, a bullet-maker would be inordinately more likely to produce a defective bullet if that very bullet was going to be used later to kill a time traveler's grandfather, or the gun would misfire, or "some little quantum fluctuation has to whisk the bullet away at the last moment," Lloyd says. In this version of time travel, the grandfather, he says, is "a tough guy to kill."This distorted probability close to the paradoxical situation is still strange, says physicist Daniel Gottesman of the Perimeter Institute in Waterloo, Canada. "The thing is, that when we modify physics in this way, weird things end up happening. And that's kind of unavoidable," he says."You're dealing with time travel. Maybe you should expect it to be weird."In an earlier paper posted in May at arXiv.org, Lloyd and his team present an experiment designed to simulate this post-selection model using photons. Though the team couldn't send the photons into the past, they could put them in quantum situations similar to those that might been countered by a time traveler. As the photons got closer and closer to being in self-inconsistent, paradoxical situations, the experiment succeeded with less and less frequency, the team found, hinting that true time travel might work the same way.

The experiments were meant to simulate freaky paths through spacetime called closed time-like curves, which carry anything traveling along them into the past and then back to the future. Einstein's equations predicted that travelers on a closed time-like curve would eventually end up back where they started. Although predicted to exist on paper, no such paths have been observed in the wild. Some physicists predict that these loops might exist in exotic regions where space-time is drastically different, such as in the depths of black holes. Despite its strange predictions, the new model forms "a nice, consistent loop," says theoretical physicist Todd Brun of the University of Southern California. The new papers make up "a really interesting body of work."These days, deciding which theory of time travel is best is largely a matter of taste. Until someone discovers a closed time-like curve in the wild, or figures out how to build a time machine, no one will know the answer, says Brun. "I don't expect these will be tested anytime soon. These are ideas. They're fun to play with."

http://www.wired.com/wiredscience/2010/08/superconductor-fractals/

Inexplicable Superconductor Fractals Hint at Higher Universal Laws By Brandon Keim August 11, 2010

What seemed to be flaws in the structure of a mystery metal may have given physicists a glimpse into as-yet-undiscovered laws of the universe. The qualities of a high-temperature superconductor ・ a compound in which electrons obey the spooky laws of quantum physics, and flow in perfect synchrony, without friction ・ appear linked to the fractal arrangements of seemingly random oxygen atoms. Those atoms weren't thought to matter, especially not in relation to the behavior of individual electrons, which exist at a scale thousands of times smaller. The findings, published Aug. 12 in Nature, are a physics equivalent of discovering a link between two utterly separate dimensions. "We don't know the theory for this," said physicist Antonio Bianconi of Rome's Sapienza University. "We just make the experimental observation that the two worlds seem to interfere."Unlike semiconductors, the metals on which modern electronics rely, superconductors allow electrons to pass through without resistance. Rather than bouncing haphazardly, the electrons' movements are perfectly synchronized. They flow like a fluid, but without viscosity. For most of the 20th century, this was possible only in certain extremely pure metals at temperatures approaching absolute zero, cold enough to quench all motion but that of quantum particles, which interact with each other in ways that defy the classic laws of space and time. Then, in the mid-1980s, physicists Karl Muller and Johannes Bednorz discovered a class of ceramic compounds in which superconductivity was possible at much higher temperatures. The temperatures were still hundreds of degrees Fahrenheit below zero, but it wasn't even thought possible. Muller and Bednorz soon won a Nobel Prize, but subsequent decades and thousands of researchers have not yielded a theory of high-temperature superconductivity. "High temperatures should destroy the quantum phenomenon," said Bianconi, who decided to investigate another odd property of these materials: They're not quite regular. Oxygen atoms roam inside, and assume random positions as they freeze."Everyone was looking at these materials as ordered and homogeneous," said Bianconi. That is not the case ・ but neither, he found, was the position of oxygen atoms truly random. Instead, they assumed complex geometries, possessing a fractal form: A small part of the pattern resembles a larger part, which in turn resembles a larger part, and so on."Such fractals are ubiquitous elsewhere in nature," wrote Leiden University theoretical physicist Ian Zaanen in an accompanying commentary, but "it comes as a complete surprise that crystal defects can accomplish this feat."If what Zaanen described as "surprisingly beautiful" patterns were all Bianconi found, the results would have been striking enough. But they appear to have a function. In Bianconi's samples, larger fractals correlated with higher superconductivity temperatures. When the fractal disappeared at a distance of 180 micrometers, superconductivity appeared at 32degrees Kelvin. When it vanished at 400 micrometers, conductivity went quantum at 42 degrees Kelvin.At -384 degrees Fahrenheit, that's still plenty cold, but it's heading towards the truly high-temperature superconductivity that Bianconi describes as "the dream" of his field, making possible miniature supercomputers that run at everyday temperatures. However, while the arrangement of oxygen atoms appears to influence the quantum behaviors of electrons, neither Bianconi nor Zaanen have any idea how that could be. That fractal arrangements are seen in so many other systems ・ from leaf patterns to stock market fluctuations to the frequency of earthquakes ・ suggests some sort of common underlying laws, but these remain speculative. According to Zaanen, the closest mathematical description of superconductive behavior comes from something called "Anti de Sitter space / Conformal Field Theory correspondence," a subset of string theory that attempts to describe the physics of black holes. That's a dramatic connection. But as Zaanen wrote, "This fractal defect structure is astonishing, and there is nothing in the textbooks even hinting at an explanation."Image: At left, the organization of oxygen atoms (blue dots) within the superconducting metal; atright, measurements of superconductivity temperature according to the distance (x- and y-axes) at which fractal organization was still evident./Nature. See Also:Quantum Entanglement Visible to the Naked Eye Quantum Physics Used to Control Mechanical SystemAmazing Starling Flocks Are Flying AvalanchesCitations: "Scale-free structural organization of oxygen interstitials in La2CuO41+y." By Michela Fratini, Nicola Poccia, Alessandro Ricci, Gaetano Campi, Manfred Burghammer, Gabriel Aeppli &Antonio Bianconi. Nature, Vol. 466 No. 7308, August 12, 2010.

http://www.wired.com/wiredscience/2010/12/wormhole-detection/

Twinkling Stars May Reveal Human-Size Wormholes

By Dave Mosher December 2, 2010

If wormholes big enough to fit a human or a spaceship exist, telescopes should be able to detect any wavering starlight the space-time shortcuts cause while moving in front of a distant star. Star brightness would fluctuate from a wormhole because of gravitational lensing, caused when a massive object (such as a galaxy) warps the fabric of space and bends light around it. The effect, which resembles the distortion of objects behind a thick lens, exaggerates with increasingly massive objects. When it comes to wormhole hunting, said Nagoya University astrophysicist Fumio Abe, looking for the distant signatures of smaller gravitational lenses, called micro lenses, is the way to go.“Gravitational micro lensing in stars has already been observed, but the variation of the brightness by a wormhole would be different from any ordinary star,” said Abe, whose wormhole-detecting methodology appears Dec. 10 in The Astrophysical Journal. Wormholes are yet-to-be-observed warpings of space and time so extreme that they connect onepoint to another through a tunnel-like throat. Such connections may be able to transport something ・ a photon of light or a spaceship ・ to another galaxy, the edge of the universe, another universe entirely or possibly backward or forward in time.“Wormholes can be a very uncomfortable subject for scientists who study general relativity because they make it possible to create time machines and travel faster than light,” said John G. Cramer, a University of Washington experimental physicist who was not involved in the study. Albert Einstein’s theory of general relativity implied the existence of gravitational microlensing, an effect proven to exist in 1919 when the sun’s gravity shifted the apparent position of a star during a total solar eclipse. There are now more than a dozen efforts underway to study the phenomenon.“We already have lots of data on gravitational lensing, so we can study the existence or nonexistence of wormholes simply by reanalyzing the data,” Abe said. “We can find wormholes if they exist or set some kind of limit on their abundance.”Physicists from around the world are intrigued by and supportive of the proposal, but all of them, Abe included, emphasize the words “if” when it comes to pondering wormhole existence.“This is a neat calculation showing that, if wormholes are out there, this would give us a fighting chance to see them,” said Matt Visser, a theoretical physicist at Victoria University of Wellington in New Zealand (also not involved in the study). “But wormholes are speculative stuff. A lot of work has been done with them, but primarily as a theoretical tool to stretch Einstein’s ideas totheir limits, to break them and see what drops out the other end.”Einstein and physicist Nathan Rosen proposed the existence of wormholes in 1935, dubbing them Einstein-Rosen bridges. Decades later, the objects were mathematically shown to be unstable: Before even a piece of light could have a chance to fly through, the throat of the wormhole would close up for good. More recent work by Michael Morris and Kip Thorne, however, suggests that highly exotic negative mass and energy ・ thought to behave counter to gravity ・ could prop open a wormhole's throat long enough for a courageous human to sneak through. Nevertheless, the challenges to create wormholes in the lab are enormous."For a wormhole about 1 meter across, big enough to fit a person, you'd need a Jupiter's worth of negative mass converted into negative energy ・ think E = mc2 ・ to hold the throat open and hope it remains stable," Visser said. "That's an incredible amount."Alien technology advanced enough to collect negative energy and create a wormhole is a more likely than a natural scenario, said Cramer and Visser, but not much can be ruled out because our knowledge is purely theoretical."Some say wormholes may have formed at a very early stage of the universe, right after the Big Bang," Abe said, noting that the energy density then may have been extreme enough to both pop wormholes into existence and stabilize them. Such large and traversable Ellis wormholes, as they're called (among other names), are the kind Abe's method may find if they're lurking in the nearby cosmos and pass in front of a star."On a graph (see below), the star's changing brightness would look something like some bump at the center, but with gutters on both sides of the peak," Abe said. "Gravitational lensing by ordinary stars does not show the gutters."With minor tweaks to telescope software, a couple of instruments could look for Abe's distinctive light signatures and confirm or constrain the existence of wormholes within a few years, Abe said. One is the Micro lensing Observations in Astrophysics telescope, and the other is the Optical Gravitational Lensing Experiment telescope. "If the wormhole exists, it shows some possibility of a traveling or time machine. But practically, using them in this way is almost impossible because they're likely very distant from Earth, probably at least 10,000 light-years," Abe said. "It may not make sense to go through a wormhole because it would take such a long time to travel to one."What many scientists would be excited about is the potential to reconcile conflicting ideas about gravity on both universe and quantum scales."If they do turn out to exist, I'll be ecstatic," Visser said. "In the meantime, they're great props for science-fiction novels and movies."

The signatures of a bubble collision: A collision (top left) induces a temperature modulation in the CMB temperature map (top right). The "blob" associated with the collision is identified by a large need let response (bottom left), and the presence of an edge is determined by a large response from the edge detection algorithm (bottom right). Image credit: Feeney, et al.(PhysOrg.com) -- By looking far out into space and observing what's going on there, scientists have been led to theorize that it all started with a Big Bang, immediately followed by a brief period of super-accelerated expansion called inflation. Perhaps this was the beginning of everything, but lately a few scientists have been wondering if something could have come before that, setting up the initial conditions for the birth of our universe. In the most recent study on pre-Big Bang science posted at arXiv.org, a team of researchers from the UK, Canada, and the US, Stephen M. Feeney, et al, have revealed that they have discovered four statistically unlikely circular patterns in the cosmic microwave background (CMB). There searchers think that these marks could be “bruises” that our universe has incurred from being bumped four times by other universes. If they turn out to be correct, it would be the first evidence that universes other than ours do exist. The idea that there are many other universes out there is not new, as scientists have previously suggested that we live in a “multiverse” consisting of an infinite number of universes. The multiverse concept stems from the idea of eternal inflation, in which the inflationary period that our universe went through right after the Big Bang was just one of many inflationary periods that different parts of space were and are still undergoing. When one part of space undergoes one of these dramatic growth spurts, it balloons into its own universe with its own physical properties. As its name suggests, eternal inflation occurs an infinite number of times, creating an infinite number of universes, resulting in the multiverse. These infinite universes are sometimes called bubble universes even though they are irregular-shaped, not round. The bubble universes can move around and occasionally collide with other bubble universes. As Feeney, et al., explain in their paper, these collisions produce inhomogeneities in the inner-bubble cosmology, which could appear in the CMB. The scientists developed an algorithm to search for bubble collisions in the CMB with specific properties, which led them to find the four circular patterns. Still, the scientists acknowledge that it is rather easy to find a variety of statistically unlikely properties in a large dataset like the CMB. The researchers emphasize that more work is needed to confirm this claim, which could come in short time from the Planck satellite, which has are solution three times better than that of WMAP (where the current data comes from), as well as an order of magnitude greater sensitivity. Nevertheless, they hope that the search for bubble collisions could provide some insight into the history of our universe, whether or not the collisions turn out to be real.“The conclusive non-detection of a bubble collision can be used to place stringent limits on theories giving rise to eternal inflation; however, if a bubble collision is verified by future data, then we will gain an insight not only into our own universe but a multiverse beyond,” there searchers write in their study. This is the second study in the past month that has used CMB data to search for what could have occurred before the Big Bang. In the first study, Roger Penrose and Vahe Gurzadyan found concentric circles with lower-than-average temperature variation in the CMB, which could be evidence for a cyclic cosmology in which Big Bangs occur over and over.More information: Stephen M. Feeney, Matthew C. Johnson, Daniel J. Mortlock, and Hiranya V.Peiris. "First Observational Tests of Eternal Inflation." arXiv:1012.1995v1 [astro-ph.CO]via: The Physics arXiv Blog

"Scientists find first evidence that many universes exist." December 17th, 2010.

http://www.physorg.com/news/2010-12-scientists-evidence-universes.htmlhttp://arstechnica.com/science/news/2010/05/quantum-teleportation-achieved-over-ten-miles-of-free-space.ars

Quantum teleportation achieved over ten miles of free space By Casey Johnston Quantum teleportation has achieved a new milestone or, should we say, a new ten-milestone: scientists have recently had success teleporting information between photons over a free space distance of nearly ten miles, an unprecedented length. The researchers who have accomplished this feat note that this brings us closer to communicating information without needing a traditional signal, and that the ten miles they have reached could span the distance between the surface of the earth and space. As we've explained before, "quantum teleportation" is quite different from how many people imagine teleportation to work. Rather than picking one thing up and placing it somewhere else, quantum teleportation involves entangling two things, like photons or ions, so their states are dependent on one another and each can be affected by the measurement of the other's state. When one of the items is sent a distance away, entanglement ensures that changing the state of one causes the other to change as well, allowing the teleportation of quantum information, if not matter. However, the distance particles can be from each other has been limited so far to a number of meters. Teleportation over distances of a few hundred meters has previously only been accomplished with the photons traveling in fiber channels to help preserve their state. In this particular experiment, researchers maximally entangled two photons using both spatial and polarization modes and sent the one with higher energy through a ten-mile-long free space channel. They found that the distant photon was still able to respond to changes in state of the photon they held onto even at this unprecedented distance. However, the long-distance teleportation of a photon is only a small step towards developing applications for the procedure. While photons are good at transmitting information, they are not as good as ions at allowing manipulation, an advancement we'd need for encryption. Researchers were also able to maintain the fidelity of the long-distance teleportation at 89percent・ decent enough for information, but still dangerous for the whole-body human teleportation that we're all looking forward to. Science, 2010. DOI: 10.1038/NPHOTON.2010.87 (About DOIs).