Review of Hyperspace by Michio Kaku 359p (1994)

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ABSTRACT

"There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact" Mark Twain-Life on the Mississippi

This is a lovely book full of fascinating info on the evolution of physics and cosmology. Its main theme is how the idea of higher dimensional geometry created by Riemann, recently extended to 24 dimensions by string theory, has revolutionized our understanding of the universe. Everyone knows that Riemann created multidimensional geometry in 1854 but it is amazing to learn that he also was a physicist who believed that it held the key to explaining the fundamental laws of physics. Maxwell´s equations did not exist then and Riemann´s untimely death at age 39 prevented his pursuit of these ideas. Both he and his British translator Clifford believed that magnetic and electric fields resulted from the bending of space in the 4th dimension-more than 50 years before Einstein! The fourth dimension became a standard subject in the popular media for the next 50 years with several stories by HG Wells using it and even Lenin wrote about it. The American mathematician Hinton had widely publicized his idea that light is a vibration in the 4th spatial dimension. Amazingly, physicists and most mathematicians forgot about it and when Einstein was looking for the math needed to encompass general relativity 60 years later, he had never heard of Riemannian geometry. He spent 3 years trying to find the equations for general relativity and only after a math friend told him about Riemann was he able to complete his work. Riemann´s equations with four dimensional metric tensors describing every point in space were incorporated almost unchanged into relativity. And on and on it goes. Since this review I have written a great deal on the language games of math and science, uncertainty, incompleteness, the limits of computation etc., so those interested should find them useful since this volume like most science frequently wanders across the line into philosophy (scientism).

Those interested in all my writings in their most recent versions may consult my e-book Philosophy, Human Nature and the Collapse of Civilization - Articles and Reviews 2006-2016 662p (2016).

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String theory can be said to date from 1919 when an obscure mathematician named Kaluza added the ten components of Einstein`s gravitational field with the 4 components of Maxwell´s electromagnetic fields and time to get the 15 components of a 5 dimensional field. He even produced the idea that the 5th spatial dimension is a sphere smaller than an atom (i.e., too small to be measured)--which remains a fundamental idea in string theory´s 10 dimensions. In 1936 the mathematician Oscar Klein postulated that the 5th dimension has the Planck length(10 to minus 33cm) which is indeed far too small to measure by any forseeable means (it requires an accelerator of 10 to the 19th BEV) and this, with thearrival in 1925 of quantum theory and the uncertainty principle pushed the geometry based Kaluza-Klein and, to some extent, even relativity theory into the background for nearly 60 years.

In quantum theory, the different forces are created by the exchange of different quanta and no geometry is used. This led to the Yang-Mills field, QED, QCD and the Standard Model of particle physics which is: all matter is quarks and leptons which interact by the exchange of different types of quanta as described by the Maxwell and Yang-Mills equations. Veneziano and Suzuki discovered the basis for string theory in 1968 when they used Euler´s beta functions to describe the strong interactions of subatomic particles. In 1970 two Japanese scientists used the idea of vibrating strings to expand on it. It is now halfway through the book and Kaku describes how he invented the first field theory of strings. Then it was shown that string theory is self consistent only in 10 and 26 dimensions and research nearly stopped for 10 years.

Then in 1984 Green and Schwarz showed that super string theory was the only self consistent theory of quantum gravity. Edward Witten became interested in the higher dimension geometric equations in physics in 1982 when he realized that gravity was impossible in quantum field theory but inevitable in the 5th dimension. In 1985 he used the highly advanced math of cohomology theory to derive a field theory of strings. This led eventually to the use of some of the most advanced (and previously unrelated) fields of math known to describe the 26 dimensional space of counterclockwise vibrations of heterotic string theory, and in some sense, the explanation of everything. Then things stalled again because millions of potential solutions to the equations are known, but which one describes only our universe; i.e., which one gives the correct field theory of strings (FTS) defined in our 4 dimensions? Nobody knows how to solve the equation using nonperturbative methods and it is often stated that we need more advanced math, I,e., math that does not yet exist. Almost everything known in particle physics has used perturbative methods.

One of the major problems is that nobody knows why string theory works—i.e., what is the underlying geometric or physical principle that makes it relevant and allows all of physics to be incorporated into the 10 (when condensed) dimensions of string theory? It is the only quantum theory that requires a fixed number of dimensions. Another bizarre result is that it has to use the modular functions invented some 60 years before by the self taught Indian math prodigy Ramanujan, who as a teenager reinvented much of modern math in his head. One of his bizarre modular functions contains a term raised to the 24th power and this is exactly the number of vibrational modes needed (24 plus 2 for spacetime or generalized in the FTS it´s 8 plus 2 or 10). The symmetries of the subatomic realm (i.e., particles) become the result of the curling up of the higher dimensional spaces.

Meanwhile, the standard model of physics was evolving but it has even more arbitrary assumptions than the inflationary theory of the big bang (Kaku says little about inflation but see my review of Guth´s book The Inflationary Universe). So GUTs (Grand Unified Theories) appeared and faded to be supplanted by supersymmetry (based on bizarre supernumbers) which integrated fermions and bosons with their spins. This led (1976) to the lovely gauge theory of supergravity in which all particles have superpartners (sparticles). Using an 11 dimensional version of the Klein-Kaluza theory to describe the 11 dimensional supergravity field allows the incorporation of matter (i.e., quarks and leptons). But sparticles were never found and supergravity turned out to be nonrenormalizable (i.e.,

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it led to infinities) so SG died.

Then came hypersurfaces described by complex numbers, on which the wave functions of the particles vibrate, thus acquiring the symmetries of the hyperspheres. So if you then apply the Kaluza-Klein theory for 4 plus N dimensions and split up its metric tensor you get everything--the Einstein equations for gravity, the Yang-Mills equations for strong and weak forces, and the Maxwell equations for the electromagnetic fields. Amazingly, it turns out that not only had Klein described the Yang-Mills field in 1938 (25 years before Yang and Mills--and they got the Nobel Prize for it!) but Y-M is now based on quantum theory which had killed interest in Kaluza-Klein for almost 60 years!!!

This brings us back to Edward Witten (whom some regard as the successor to Einstein) and superstring theory, in which matter is now the harmony of extremely small vibrating strings which can fuse and break up. It accounts for almost everything and is the first quantum theory of gravity with finite quantum corrections. In spite of its highly abstract nature, lack of any experimentally verifiable predictions, lack of a unique solution for our universe-it has millions of solutions (orbifolds), many(all?) of which could have properties that might make our universe impossible- and any rational explanation for why it works (i.e. no conceptual framework uniting gravity and quantum theory), it has a compelling, almost religious appeal for many physicists because, starting only from geometry and the condition that strings move self consistently in spacetime we get magnetism, electricity, spacetime, general relativity, Klein-Kaluza, supergravity, the standard model and the Grand Unified Theory--it binds matter,energy and spacetime. String theory does not however, predict or explain the properties of particles nor the paradoxes of quantum mechanics, uncertainty and entanglement (Bell´s theorem).

Though I don´t think Kaku says this anywhere, it is so general and so powerful that one gets the feeling that it could explain anything in any possible universe and in that case it does not really explain anything at all--it becomes the mathematical equivalent of `God made it that way`. So, it may eventually begin to lose its appeal as a final explanation (as it has for many physicists).

So, we still can ask the same question as Kaluza in 1919--where is the 5th dimension?-- and still pursue the same answer given by Klein in 1926.

Quantum theory and quantum tunneling explain the apparent violation of the conservation of energy shown by radioactive decay. It might explain the sudden appearance of a 4 and a 6 D universe from a 10D one. Because the false vacuum of a 10D universe was unstable we assume, but cannot prove, that it quantum tunneled to a lower energy state, breaking symmetry and creating a true vacuum in 4D space. But if it is not the true vacuum then one day a small bubble may appear and enlarge at the speed of light until it destroys our universe. Our 4D universe can curl up in 4 ways but a 10D one can curl up in millions of ways. So, to find the right one, we need to solve the field theory of strings using the theory of phase transitions--the most difficult problem in quantum theory.

In 1994 the heterotic string theory of David Gross (one of the four Princeton physicists known as the Princeton string quartet) showed that the quantum unit of gravity emerges as the smallest vibration of a closed string.

Since the laws of physics break down at the very small distances and large energies of the big bang, we need a string theory with 10 dimensions that breaks into 6 plus 4 to create twin universes of which the 6 is an orbifold too small to observe. Kaku says that only 10D superstring theory can explain what happens before the big bang but of course Valenkin and Hawking and others have alternatives. (see my review of Guth).

Even in the string theory of the big bang, a small piece of the universe must inflate by a factor of 10 to the 50th, so apparently all of inflation is included. It has been frequently theorized that black holes may be tunnels in spacetime to other universes. But it appears we don´t know if black holes really pinch off hyperspheres of spacetime in which light is trapped.

Along with its untestability and lack of any conceptual foundation, a further problem is that the math is so general that it has millions of solutions(orbifolds) which include all of physics(General relativity, Grand Unified Theories etc) and there is no way to decide which one of them describes our universe. Some(or all?) of the solutions have properties that might make life, or even our universe, impossible. One cannot simply put a computer to work to decide which solution is right for our universe for the same reasons one cannot solve quantum tunneling etc.--infinite time is required.

Though neither Kaku nor anyone else I have read has said so, it seems that the math of 26 D geometry is so powerful that it could describe any possible universe. In this case it is understandable why it lacks a conceptual foundation as it has no special relation to our universe. Anything expressible as an algorithm or number can be derived from anything else by writing the appropriate algorithm or codec, so the rules of chess, Avogadro´s number, the dimensions of the great pyramid and the dynamics of ant colonies are deriveable too.

One of the things that makes many think math is out there in the universe rather than in here in our minds. Naively, one could say that the structure of the universe makes, our mind so is it a surprise that our thoughts (e.g., mathematics) mirror the universe? The debate on the 'unreasonable effectiveness of mathematics (Wigner) continues but to me it is just another group of confusions about which language games we are playing (see my other articles). For a recent excellent article by an engineer (though of course with no clue about Wittgenstein or language games) see Derek Abbott 'The reasonable ineffectiveness of mathematics' Vol. 101, 0018-9219 _ 2013 IEEE No. 10, October 2013 | Proceedings of the IEEE 2147-2153.

The compelling way in which pure math yields physical results is illustrated by the discovery of a mathematician who was just looking for another solution to the equations of general relativity. By assuming a black hole rotates, Roy Kern in 1963 found a solution and thus an exact representation of black holes. They will collapse into a ring so that objects approaching from the top or bottom will experience a finite curvature (gravity) so it might be able to get to the mirror universe which exists on the 'other side` of spacetime. But, at this density of mass-energy, general relativity breaks down and quantum effects probably dominate so maybe we can find an answer with string theory. Likewise with time travel.

By making various assumptions about the universe one can come up with many different solutions to relativity. In 1949 Godel (he of Incompleteness Theorem fame) showed that if one assumes the universe rotates, time can bend in a circle or CTC (Closed Timelike Circle). It turns out that van Stockum had derived a CTC solution in 1936 (pointed out by cosmologist Frank Tipler, who recently became infamous for his book 'proving' the existence of God from physics) and many have done so since Godel, usually using black holes or an expanding universe. It is now realized that there are an infinite number of such `pathological` solutions to the equations of general relativity. It appears that all CTC will violate causality. As one of the principal founders of quantum cosmology, Hawking proposed that wormholes could be used to enter other universes. Ever daring, he used quantum theory to treat the entire universe as a quantum particle represented by a wave function which will be large for our universe but small for others.

Assuming they are connected by wormholes, Sidney Coleman summed the contributions of an infinite series of universes, to show that if the cosmological constant (CC) is zero then the wave function is large (i.e., high probability). If the CC is not zero, then that universe has zero probability (i.e., the effect of an infinite number of parallel universes is to keep CC zero in ours), which means the CC cancels to one part in 10 to the 100th!

Acting on a request from Carl Sagan, Thorne et al (1985) discovered `transversible wormholes` --the first ones that were actually feasible in the sense that a human might actually survive using them. It seems theoretically possible to create one using the negative energy(i.e., less than in a vacuum) of the Casimir effect (a quantum effect thought to occur everywhere all the time) in which particle-antiparticle pairs appear and self annihilate at very high rates.

Godel showed that math is 'incomplete' (see my articles for a Wittgensteinian analysis of this) and physicists have shown that quantum theory is also 'incomplete' (e.g., Schrodinger´s cat is dead and alive at the same time) but the string theory of quantum gravity has an equation (wave function) for the entire universe and there is no longer an observer and an observed because it is a 10 dimensional theory and so renormalizable. However the cosmic wave function is a composite of all possible universes so indeterminacy remains. The smallest quantum unit is the space of all possible universes, in some of which the cat is dead and some alive. Quantum theory and string theory seem very reductionistic, but one equation for the universe seems as holistic as it´s possible to get!

Superstring theory (SST) has stretched math to its limits and needs more advanced math to evolve. Physics needs the self consistent structures of math so it combines topology and the Reimannian geometry of general relativity (ie, groups of quantum field theories) to eliminate the infinities (i.e., renormalize) of the quantum theory of gravity.

It seems to me that the most complex products of the brain--SST and topology, are recursive to quantum field theory and the behavior of particles and the entire universe. Though Kaku does not discuss incompleteness, we know that math is proven (Godel, Chaitin, etc.) to be forever necessarily incomplete --i.e., infinitely many well formed theorems in any mathematical system can never be proven to be true or false. Then, since math and physics are now fused at the highest level (Superstring theory), the one can create a language game in which there is a nontrivial sense in which physics and the whole universe and the mind are 'incomplete' as well. What is the significance if many laws of physics in some possible universes (or ours) and/or many thoughts in our brain are never to be consistent with or derivable from the others? Or rather there is no significance or many views or concepts (language games) of 'significance'.

String theory unites physics with many of the most advanced and formerly separate areas of math--SuperLie and Kac-Moody algebras, modular functions, finite groups, algebraic topology, Riemannian geometry and cohomology theory. But it remains without a conceptual basis, so we are left to wonder if there is anything other than powerful math that unites quantum theory and gravitation.

Kaku does not dwell on the problem of emergence, but physical scientists can rarely resist reductionism. However, the quantum field equations are so difficult that they cannot be solved for one atom and not even for a vacuum. They require an infinite time to compute. One only finds out the emergent properties of things that result from combining smaller things by seeing what they are like after the fact--whether they are quarks making a proton, molecules making cells, or stars making a universe. One also has uncertainty and chaos. We have no way to determine in what way and when a pile of sand will collapse. Physics has to wait for the results at the micro (subatomic particles) and macro (cosmological observations) scales before advancing and it is full of uncertainty and bizarre phenomena. Also, there seems to be no way we can ever test SST (the theories change constantly but the bottom line is that we will never be able to do experiments at the requisite energy (10 to the 19th BEV) –i.e., the Planck length (10 to -33cm)) So, physics and even math (incompleteness, etc.) seem to be just as empirical and 'unsolvable' as biology (consciousness, free will) and we must accept the 'uncertainty' of our most advanced concepts as we do that of our everyday life.