# Chapter 16: Is Observer Physics A New Kind of Science?

At the beginning of this book I asserted my belief that observer physics will become a new paradigm in this century and perhaps for a long time to come. Now that I have hazarded a few preliminary forays to explore the potential of this new scientific paradigm, perhaps it is time to evaluate my modest efforts and compare it to some contemporary efforts (right or wrong) being made by innovators toward cultivating fresh viewpoints in physics. My chosen examples from among many are Stephen Wolfram (randomness, complexity, and automatons), Laurent Notalle (fractal space-time), and Alexander Wissner-Gross (causal entropic forces).

The first question we should address when considering the potential value of observer physics is whether it can qualify as a science. In the introduction I proposed a definition of **science as an attempt to set in order the shared facts of experience.** The reports compiled by scientists are attempts to describe our shared experience in an orderly and coherent fashion so that we can understand how the world functions and perhaps also apply the knowledge gained in ways that improve the quality of human experience.

As a science observer physics must include theoretical hypotheses and experiments that verify the hypotheses – knowledge and experience that match. In this set of essays as much as possible I have presented theories and then suggested experiments that readers may easily perform to verify the ideas with experiential data, often citing the theoretical and experimental work of other scientists past and present when more sophisticated experiments are required as evidence. If evidence is lacking or uncertain, I suggest possible approaches and encourage creative researchers to pursue them or discover new insights and methods.

Everything that I have put forth in these essays is subject to critical examination and verification. In case errors are found in the mathematics, reasoning, or any other claims, the material is subject to scrutiny, discussion, revision or refutation. In that sense I believe my approach stands squarely in the scientific tradition.

Observer physics is a broadening and generalizing of classical and modern physics. For much of past history scholarly work was primarily subjective, and theories were often promoted without recourse to verification by experience or experiment. The rise of modern science has been characterized by two major qualities. First, the "objective" spirit came to the fore in the sense that scientists recognized that theories are much more meaningful if they accord with and accurately describe experience. This led to development of the experimental method. Second, scientists discovered that mathematics is a precision tool for concisely and often elegantly describing scientific theories and principles. Accurate measurements from experiments could then be applied to the theoretical mathematical model to confirm or deny the validity of the descriptive model.

Unfortunately, the enthusiasm to be objective seems to have led to forgetting that science is carried out by and for humans, and that humans pursue scientific endeavors for reasons that are determined by their personal and collective viewpoints and goals. That installs a natural bias in scientific research that is easily overlooked. Furthermore, as scientific skills of measurement have become increasingly precise, scientists have discovered that there are inherent limits in the very process of measurement that are *a priori* imposed by the nature of what is measured, the measurement tools, and the viewpoint choices of the experimenter. As scientific measurements became ever more subtle and refined, it became increasingly obvious that the observer drastically influences whatever he observes. The more intimate the observer's observation becomes, the more powerful her influence is on what is observed. Thus we might reasonably hazard that the observer plays a fundamental role in any scientific endeavor and therefore must be accorded prior importance in the framing of any hypothesis and the interpretation of any experimental results.

Just as relativity theory and quantum mechanics are natural extensions and generalizations of classical physics, observer physics is a further extension and generalization of both classical and modern (relativistic and quantum) physics.

Therefore, a fundamental principle of observer physics is that it accepts as valid any accurate experimental data, and either accepts as is or refines and extends existing theories that are supported by experimental data.

A good example of the way we can refine and clarify our understanding of classical physics is by our analysis of Newton's second law in the light of observer physics. Newton's formula $F = ma$ is accurate as it stands within a certain range of application, but we not only must update it under relativistic and quantum conditions, we must also make clear that it only holds under the special conditions in which an observer participates in an experience or experiment involving the use of force to resist an object that has an inertial mass potential. There is no way to determine whether any phenomenon has that potential without exerting a resistive force to test it. A projected holographic image may look very real and solid, but if you try to grasp it, you discover it is a projected phase wave that behaves like a mirage.

Much of what we experience in our lives these days qualifies as phase wave phenomena and other interactions that are devoid of mass and might as well be part of a television show. Only experiences that involve a person actively imposing force to resist a mass qualify under Newton's law. Since such resistances are imposed by the observer, we may reasonably infer that universal application of Newton's second law is an attempt by an observer to impose his personal resistances on a neutral universe and then abdicate personal responsibility. **The widely held notion that forces and masses exist independent of the observer may be a gigantic transparent belief!** I challenge the scientific community to devise an experiment that will prove otherwise.

If you assume that things have mass, then you must accept that they have inertia by Newton's first law. If you want to change them, the first law states that they will resist change and want to stay the way they are. Moreover, by Newton's third law, they will resist change with an equal and opposite reaction to whatever we do to them. Oh dear! What does all this say about the exercise of force to gain compliance from materials, living organisms, and other cohabitants of our planet. It sounds like a certain recipe for enslaving ourselves to imaginary adversaries and problems. Maybe Newton's great laws of physics have indoctrinated us into self-imposed slavery!

What if Newton is right, but only in terms of what happens when an observer resists his "inert" world. What if it is also true that everything is dynamically changing all the time according to its natural rhythms, passing through day and night, summer and winter, rain and shine, and innumerable other simultaneous processes. What if, instead of trying to force things to change faster (accelerate) in the direction we want (or don't want) them to go, maybe we could first observe how things are trending by their own natures and then facilitate that natural process in an effortless and non-intrusive manner so as to gain the outcome we want as well as the outcome "things want" by their own natural tendencies. We might even be able to enjoy a peaceful world living in harmony with the seasonal changes of our environment instead of struggling to conquer nature and control the population.

**A New Kind of Science**

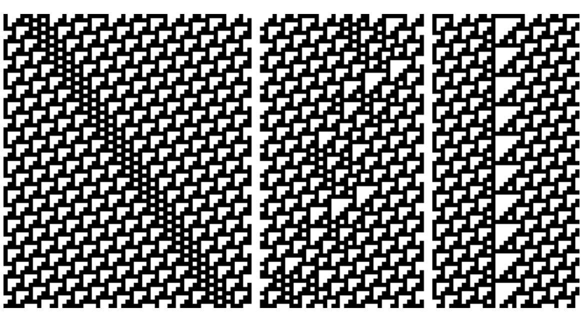
About eleven years ago when I was writing the first draft of this work I came upon a fat, new, and fascinating book by Stephen Wolfram with the outrageously bold title, **A New Kind of Science** (Champaign, IL: Wolfram Media, Inc., 2002). Early in his career Wolfram, among other precocious projects in physics and mathematics, wrote a pseudo-random number generator that has become widely used in computers. I also knew of Wolfram on the Internet as the creator of a powerful software program **Mathematica** and the well-known website **Wolfram MathWorld**. (For more details about Wolfram's life and works, see **Wikipedia**, "Stephen Wolfram" and Wolfram's website, www.stephenwolfram.com.)

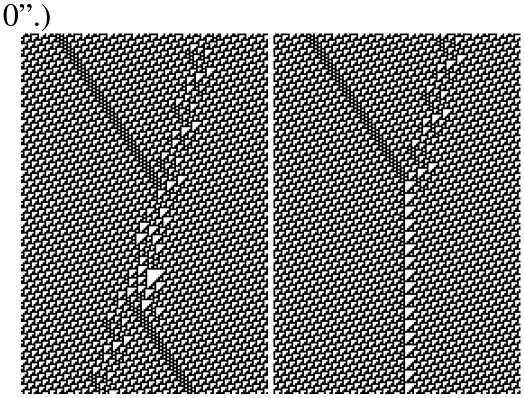
I find the title of Wolfram's book ambitious to say the least and would like to comment on his ideas in detail, because they are related to and an example of the trend that will eventually lead us to the new paradigm of observer physics. The main research tool used by Wolfram for his book is the systematic study of **cellular automata**, a field that may well become a new scientific discipline. But Wolfram's vision is much broader. He feels he has identified some global principles, and he is deeply exploring the boundaries and interactions between the mental (mathematical) and physical worlds. This automatically makes him a major pioneer in observer physics. As for his claim of a "New Kind of Science", I think it is more like an interesting extension of existing science. But that does not detract from the creativity of his approach.

As a result of his work on cellular automata and complexity "Wolfram's conclusion is that the universe is digital in its nature, and runs on fundamental laws which can be described as simple programs. He predicts that a realization of this within the scientific communities will have a major and revolutionary influence on physics, chemistry and biology and the majority of the scientific areas in general, which is the reason for the book's title." (**Wikipedia**, "Stephen Wolfram".) In my research on observer physics I have come to a similar conclusion, and believe that one of the problems scientists face in using mathematics as a primary tool for theoretical physics research is that much of mathematics assumes continuity, whereas the digital world is composed of discrete quanta. Continuity only holds in an undefined domain such as transcendental awareness, which, for example, leads to a fundamental problem with any mathematics based on the real number system (a set that consists mostly of undefined numbers), and that includes the way most calculus is done. Sorting out when it is appropriate to work with defined entities and when it is appropriate to explore by means of undefined entities becomes a critical issue for physicists.

A key theme of Wolfram's work is what he calls the principle of "computational equivalence" -- the ability of mathematics to mimic the physical world – and a phenomenon I discussed at some length in chapter 1. If I understand his idea of equivalence correctly, he means by the idea that as a computational system (such as a computer program or mathematical algorithm) grows in complexity, there is a threshold beyond which **all systems** behave the same. (Does he mean that God -- and the aliens -- are no smarter than we are – as long as we all reach computational equivalence? Is this anthropomorphic jingoism? Or does it just mean that everyone is equally good at making a mess?) Perhaps Wolfram is talking here about the limit where complexity becomes pure randomness.

Wolfram's other idea of "computational irreducibility" apparently refers to the notion that any model of a system at some point essentially reproduces the system in another medium with the same complexity. Related to this is the mathematical notion of "universality" – a certain program can be set up to emulate a whole class of programs. A similar idea is the notion that you can emulate algebra with geometry and vice versa. In 1985 Wolfram conjectured that his Rule 110 Cellular Automaton was Turing complete and capable of universal computation and around the year 2000 Matthew Cook proved this to be the case. (See **Wikipedia**, “Rule 110”.)





There are an infinite number of localized patterns called “spaceships” embedded in the infinitely repeating background of Rule 110. The background repeats itself every 7 iterations. Above on the left are three localized patterns. On the right are examples of the three localized patterns interacting within the stable background. (For spaceships and an animated example from mathematician John Conway’s **Game of Life** cellular automaton, see **Wikipedia**, “Spaceship (cellular automaton)”.)

Wolfram's starting point in the creation of his "New Kind of Science" was his discovery going back perhaps to his **random number generating algorithm** (an oxymoron?) that very simple programs can produce great complexity and perhaps even randomness. This is not really a new discovery. Mathematicians have known this since the discovery that a simple and precise ratio such as *pi* is an irrational quantity that generates a decimal with an infinite string of "randomly" sequenced digits. Linguists are familiar with ways to generate randomness (or at least great complexity) from simple grammars, and more recently the fractal and chaos people have made a great deal of progress generating infinite complexity with simple mathematical structures such as the Mandelbrot set. In **Observer Physics** we discuss the example of the growth equation with the Verhulst factor included so as to make the system nonlinear. What may be special about Wolfram's approach is the importance and generality he attaches to this principle. Its flowering as a principle definitely is a product of the computer age. But, although Wolfram may not be the first to notice that a new kind of science is emerging, he is definitely one of the significant pioneers in this new science.

**What Does Wolfram Mean by "A New Kind of Science"?**

Wolfram has developed a wonderful way of systematically exploring the behavior of computer programs by defining a simple type of algorithm with a finite number of variations in its instruction sequence and content. He then numbers each possible program in the set and then test runs each program variation, making a printout as evidence of the program's behavior. This is an extension of what people were already doing with computers to model behaviors of systems. But Wolfram has carried it to a more abstract and general level as a discipline in its own right. Like Mandelbrot in his breakthrough fractal research Wolfram uses the computer's powerful graphics capability to explore simple algorithms, exploiting the human capability to analyze data in parallel through visual scanning of patterns in data printouts. Combining this with the computer's high-speed iterative power gives awesome results. Wolfram creatively uses the identity of geometry and algebra the same way that Mandelbrot and others have to speed his research and make it more accessible. Pictures are worth a thousand words. Another interesting design feature of Wolfram's experiment is that he restricts himself only to using very simple discrete automata that proceed step by step rather than as a continuum.

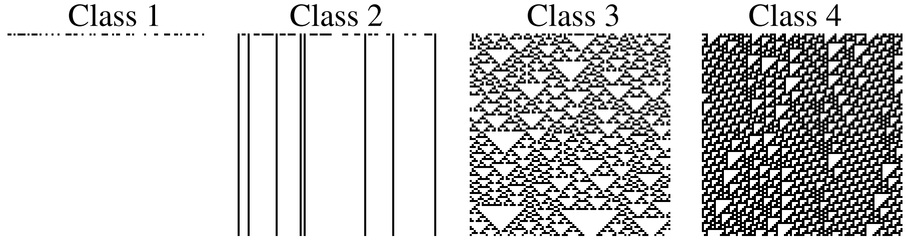
Wolfram has come up with a general typology of system behavior with regard to its most general level of organization. He designs a system with 8 steps and 256 possible "rules". He identifies four general types of behavior (pp. 51-52). There are really five types of system "equilibrium" that show increasing levels of complexity, but Wolfram combines the first two (what I call types 0 and 1). He really should keep them separate, because perfect homogeneity and total random mixing are the opposite limits of a spectrum. Also, for a nice symmetry in his taxonomy, he should divide Type 4 into periodic islands and nested islands. Here is Wolfram's typology with my refinements. His rules 0 to 255 are on p. 55 and at **Wikipedia**, "Elementary cellular automaton". Each output begins with a blank page with a dot in the middle of the top "row" or a random sequence and then the computer prints out each step of the program line by line as an evolving graphic. In his most primitive set of 256 rules many end up blank or with a straight or diagonal line. Others get quite complex. He arranges the sequence of rules so you can see that the outputs are also complementary, like the positive or negative prints of a photograph (black patterns on a white background, and white patterns on a black background). Here are the types, first with my classification and then with Wolfram's.

Type 0: Homogeneity without change (total simplicity)
**Type 1:** Repetition (periodicity, oscillation); more generally -- "linking"
**Type 2:** Nesting (periodicity with embedded structures); fractals
**Type 3:** Randomness (chaos)
**Type 4a:** Local Structures (chaos with local islands of repetitive order)
Type 4b: Local Structures (chaos with islands of nested structures)
Type 4c: Local Structures (chaos with local islands that migrate and/or evolve)

Below is Wolfram's classification (**Wikipedia**, "Elementary_cellular_automaton"):

- Class 1: Cellular automata which rapidly converge to a uniform state. Examples are rules 0, 32, 160 and 232.
- Class 2: Cellular automata which rapidly converge to a repetitive or stable state. Examples are rules 4, 108, 218 and 250.
- Class 3: Cellular automata which appear to remain in a random state. Examples are rules 22, 30, 126, 150, 182.
- Class 4: Cellular automata which form areas of repetitive or stable states, but also form structures that interact with each other in complicated ways. An example is rule 110. Rule 110 has been shown to be capable of universal computation.[

Class 1 Class 2 Class 3 Class 4



Rule 0 Rule 4 Rule 22 Rule 110

Wolfram tallies the percentages of each type. Types 0, 1, and 2 exist in blank (homogeneous) environments. Types 3, 4a, and 4b exist in chaotic (random) environments. Of course we can also add mixing of repetition and nesting at both levels (homogeneous and chaotic). There may also be a further distinction of inanimate and animate creatures (such as "spaceships") at the outer regions of both levels unless such phenomena only occur in type 4. We also do not know if animate forms are endemic and/or exclusive to type 4 or not. But obviously they do not appear in class 0, and, depending on point of view, may not appear in types 1 and 2. For example, vertical stripes can be seen as periodic and nonmoving, whereas the same stripes tilted diagonally can be seen as migrating "non-locally" in the same way as the migrating islands of type 4. Plaid squares tilted form crisscross hatches like Rule 110. These can be regular or irregular. If we have a random field of black and white squares, presumably we could find a viewpoint that would neatly separate the two into the two classes. For example, if you mix salt and pepper in a jar, you can add water, dissolve the salt, strain out the pepper from the salt water, and then allow the water to evaporate, leaving the salt and pepper re-separated for a nice local reversal of entropy. The water acts as an attractor that shifts a class 3 system into a class 1 system.

Wolfram says 14% of the rules generate complicated patterns, the most common of which are nested patterns. Although 24 have such patterns, they only fall into three different forms. Ten out of 256 (3.9%) show apparent randomness.

Wolfram finds that extremely simple systems produce only simple outcomes, but a threshold involving only a surprisingly small amount of complexity can lead to remarkable complexity. He also finds that additional complexity of the rules does not necessarily add to the richness of the overall dynamic complexity of the system.

Wolfram notes, as the chaos researchers do, that randomness can simplify by means of "attractors". Thus reversibility is possible for all systems, but exact path reversibility only occurs in periodic, nested, or pseudo-random (not pseudo-periodic or chaotic) systems. Homogeneity and randomness both wipe out path information, but you still can go back and forth between homogeneity and randomness. You just have multiple possible pathways -- a fairly obvious condition. (Recall our discussion of tipping tops in chapter 15.)

Wolfram has noticed that Class 4 systems have the interesting property of non-local communication via animated local orderly structures that can move about and interact with other parts of the system. If Wolfram's conjecture that all class 4 systems have animation is true, that is a major contribution. Unfortunately he does not prove it. He just gives some good examples and makes a conjecture. Rule 110 sometimes produces graphics that look like rigid scattering diagrams. Maybe this is the primordial source of the archetype for the "animal". Some automata just sit still like rocks. Some grow like plants. And some range about like beasts, or maybe just wandering asteroids.

Wolfram's classes are not new. Perhaps his assertion that they are universal and general is new. For example, in grammar the blank page represents homogeneity -- we call it "writer's block". Conjunction is repetition of a grammatical structure, usually with linkage by "and" or "but", or perhaps just with commas. Sentences are periodic grammatical structures. Essays are organized in a fractal manner as a theme with chapters, paragraphs, sentences, phrases, words, and letters – all components of which restate, embellish, and enrich the basic theme. So language is highly nested with embedded structures. In literary circles randomness is usually referred to as "creative writing". You never know what the writer is coming up with next.

This brings up another dimension to randomness. Just typing random letters or words is NOT creative writing. There's a difference. Creativity comes from unexpected, unpredictable shifts to different levels of awareness or points of view, but with an underlying unspoken orderliness that conveys a message or a feeling. “Unexpectedness” is not necessarily the same as randomness. You can have particles scattered randomly all over a screen, or you can choose a topic and view it from many different random viewpoints. In other words, the screen is the theme and the particles are the various viewpoints. Local structures come up in language as the use of refrains, asides, digressions, and parenthetical expressions, and themes within a complex framework. In my discussion of decimals I give examples of these various classes in number theory. Wolfram might take a look at Hockett's famous article in **Scientific American** (203/3, 1960): "The Origin of Speech." Particularly relevant are the design features of productivity and arbitrariness. You can find a summary of this classic article on the Internet. (Also see **Observer Physics**, chapter 1).

In Chapter 11 of **Observer Physics** I discuss invariance, starting with the notion of the Hamiltonian and the conservation laws, symmetries, and invariance relations in physics. Embedded in that discussion is a long section about simple mechanical models such as cams and ratchets that describes a whole range of techniques for using symmetry breaking and phase locking to form localized equilibrium states embedded in larger systems. The range goes from complete homogeneity (obviously self-reversible), to periodicity, to nested structures, to thermodynamically randomized systems, to locally phase locked systems. I also give models of quantum techniques for shifting from one style to another or moving from one localized island to another, including also techniques for preventing island shifting -- non-local or nested phase locking.

Perhaps one of Wolfram's key contributions to observer physics is his discovery that with computer experiments you can deliberately **objectify** a precise mental-mathematical expression as a computer program and then systematically **observe** the behavior of the mental construction as a physical phenomenon via the computer output (p. 109.) He thereby extends his defined ideas step by step into physical forms. This is important, because, as debuggers well know, some computer programs behave in unpredictable ways that one would never guess without exploring the outputs of the programs at some length.

However, just as Einstein's principle of equivalence needs to be "flipped" to "conjugate equivalence", so also the principle of computational equivalence needs to be "flipped" by the mirror lens of certainty/uncertainty. (See Chapter 1 and Chapter 6 of **Observer Physics**.) The outputs of Wolfram's cellular automata programs may seem like mathematical structures, but computer printouts really follow the rules of quantum waveforms and entropy. As Wolfram extends the Mental Space into the World Space, the question then arises -- just where is the crossover point between mind and matter? Wolfram's techniques are reminiscent of magician Doug Henning's sliding knots -- he is sliding the Mind-World crossover further from the Mental World in the direction of the Physical World. A program such as Transcendental Meditation allows one to slide it in the other direction, and the Avatar technology allows you to slide crossover “knots” in any direction you like.

There is a clear threshold at the transition from homogeneity to incipient complexity (i.e., simple systems that modulate). Then there is a continuum of increasing complexity that is only defined by the observer. Then there is a "quantum leap" from complexity to "chaos". Randomness is the limit of infinite complexity -- no rules at all, though you can embed rules and hierarchies of rules within that background of no rules. One thing is certain: an algorithm stored as coded instructions in a computer, is a physical record of the mental “object”. A printout on paper is an expression of the content of the automaton program, and all printouts of the same program look the same. Is a “random” output of an automaton really random if each printout of the program’s run when compared is found to give the same exact result that looks random? It is clear that both the physical embodiment of the program instructions in the computer and any individual copy of a printout are physical objects subject to the ever-changing influences of the environment. The mental automaton is immortal and exists forever as a potential instruction set with its endless operational potential, but its physical embodiment is very much mortal and lasts only as long as its individual embodiment, say as patterns of symbols inscribed on paper with ink. The crossover point occurs as soon as the mental structure takes on a physical embodiment of any kind.

**Randomness**

Wolfram writes in great detail about randomness and complexity, but only on p. 552 of his 2½ inch thick tome does he get around to probing for a good definition of randomness. After pecking at it lamely for a few pages, he ends up with the notion that **when something is random, no "simple program" can "detect any regularities"** (p. 556). **The irony of this definition arises from his original claim that simple programs can generate randomness and complexity.** It sounds like he is admitting that his random number generator really only generates **pseudo**-random sequences of numbers.

Wolfram asserts, but does not prove, that if no simple program can detect any regularity in the object of examination it must be random. What about a complex program? So he makes an assertion about randomness without giving us a concrete "randomness" test. He's talking about a "regularity" test. Where is his "randomness" test? How do you prove something is truly random with a finite proof? If I'm right about randomness being a limit at infinity, then **there is no randomness test** in the physical world. This is the fundamental problem with empirical testing. It can't prove anything in a finite batch of tests, because it may not yet have encountered exceptions to the hypothesis under study, and the test method or range may be way off base due to transparent beliefs.

The goes back to our discussion of real numbers. Randomness is non-local and infinite. You can never tell in a finite range whether or not at some point it may suddenly "regularize" or reveal a deep level of innate regularity. If you have a finite field of random data, then you can simply photograph it and print as many copies as you like and you no longer have randomness. True randomness is the field of **undefined awareness**, the field of all possibilities taken at once. You experience that when you transcend in meditation. Maybe transcending any system is the only route to pure randomness (see below). We will come back to this when we consider the ideas of Wissner-Gross.

**Randomness and Complexity**

Wolfram notes the apparent similarity of **complexity** to randomness, and after whacking at that notion for a while, he arrives (p. 559) at the idea that something "seems" complex if we can't extract a "simple description" of it. **This again is ironic in the light of his demonstration of how very simple algorithms can generate extremely complex behavior.** Isn't his thesis telling us that, for example, **Rule 30 is a brief, but complete and precise, description of a certain style of complex, or perhaps even totally random, behavior**? Why doesn't he come out and state clearly that randomness is the upper limit to complexity? If this is so, then the outputs of any two programs that generate total randomness are essentially identical – the end game of computational equivalence. If the threshold for the onset of true randomness is at infinity, there may be no finite test for it. On the other hand, the onset of complexity (from simplicity) is finite, but subjective (**observer-defined**.) Palmer (**ReSurfacing**, p. 5) suggests that **something seems complex because it doesn't fit in with what you already believe.** He means by this that complexity is observer-defined. A math professor finds calculus simple, but an average elementary school student finds it complex. Eventually, after a bit of indoctrination, the student may also find calculus simple. Or he may put some attention on it, figure it out, and then find it simple.

Wolfram asks over and over the rhetorical question: **What causes randomness**? He finds lots of examples of inherent randomness, systems that perpetuate randomness, and algorithms that generate apparent randomness. But he never answers the question of what it is about the third type -- the randomness generator -- that causes randomness – and he of all people should know something about that.

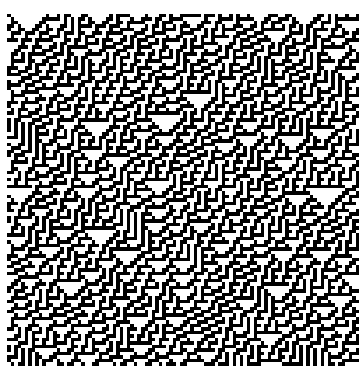
### Randomness Generators

Probably the only way to generate truly random sequences of events is to use a device that has a mechanical interface with nature – and that **assumes that nature is totally or in certain aspects random and does not just appear random due to a limited viewpoint.** For example, a device mechanically flips a coin in a box and then records with OCR the result of the toss – a head or a tail. Does the mechanical energy imparted to the coin cause it to follow a certain pattern? Perhaps a device shoots individual electrons or photons through a slit and records where they hit on a sensitive screen. As far as we know the particles distribute themselves randomly within the wave form set up by the system design. We presume that both of these mechanical actions result in random outcomes that can then be mechanically recorded. By definition any algorithm will only approximate randomness with very complex sequences of behavior because each action is defined by the set of instructions. Every time you run the program, you get the same output unless in between some sort of interface with the un-programmed quantum physical world occurs (such as with the electron slit experiment). The printouts of Wolfram's programs that seem very random are not so by definition because they follow a strict algorithm. At best they are pseudo-random unless there is a mathematical proof that the program will never repeat a pattern (like repeated calculations of *pi*) or, better yet, will give an unpredictable result every time you run it.

### Meditation and Randomness

In **Observer Physics** I provide a definitive experiential model you can test for yourself. Consider, for example, the TM technique. It is a very simple algorithm. Sit down. Close the eyes. Wait a few seconds. Mentally "pick up" (deliberately begin to think) the mantra. Continue thinking the mantra in the effortless way that you have been instructed to use it. . . . This is a very orderly and simple algorithm. What are the results? From time to time the mantra disappears, and then -- sometimes after a perceivable-after-the-fact gap -- you find yourself thinking random thoughts. Then you go back to mentally repeating the mantra. TM thus appears to be a Class 4 system. It starts with a simple repetitive program, but develops into a complex field with localized fractal versions of the mantra (the same pattern at various scales of intensity, clarity, subtlety, and so on) embedded in a background of random thoughts and experiences that are present in the internal and external environment but without any logical or content-wise connection to the algorithmic procedure of the meditation other than that they are expected side effects of the process. Oddly enough, this is a very comfortable and natural experience -- suggesting that it is inherent to our nature. Perhaps we are "Class 4 Creatures".

Wolfram might counter: Well, the random thoughts come from "outside" the system. True enough, Wolfram has a very precisely defined algorithm and implements it in the very controlled and limited environment of a computer. But what is "outside"? The system we are using is consciousness. Does not his principle of computational equivalence proclaim that the randomness generated by a natural phenomenon, or a computer program or a human consciousness, are equivalent? The point here (discussed in detail in **Observer Physics** from an analysis of consciousness and attention) is that this "simple" process involves initial conditions that begin in a state of extreme bias (ordinary waking state consciousness, deliberately thinking the mantra). Attention is awareness flowing in a particular direction – like the flow of the computer program step by step. The direction of attention initially is biased to the mantra. But then it shifts to subtler levels of appreciating the same bias. As the attention gets more and more focused in that appreciation, it actually expends less and less energy and begins to expand. The system relaxes its bias. At some point it passes the threshold of bias and relaxes into a completely unbiased state. In that undefined condition anything is possible. Only the wave function of the body and mind of the individual generates higher probabilities for certain thought events. They function as a sort of background bias, a larger nested island complex of probability in the ocean of mental thermal chaos. But the ensuing thought events occur quite randomly -- within the probability guidelines of the system. The same is true of the automaton Rule 30. Wolfram uses Rule 30 as the random number generating "mantra" for his random number generator. Who knows? Rule 30 might even be a good technique for meditating. See the defined "mantra" ∇ floating at different scales among random thoughts in a sea of undefined awareness?



| Rule 30: | 111 | 110 | 101 | 100 | 011 | 010 | 001 | 000 |
|---|---|---|---|---|---|---|---|---|
| | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |

Wolfram's "Rules" are just the binary numbers 0-7 (000-111) in the top row and a single byte (8-bit) binary number in the second row. His 256 rules are just the sequential listing of the 256 bytes in order. For more details on this see **Wikipedia**, “Wolfram code”, “Elementary cellular automaton” [which has samples of the integer sequences and **graphic images of all 88 in-equivalent cases among the 256 1-D rules** defined by Wolfram], and related resources such as Sloane’s OEIS [On-Line Encyclopedia of Integer Sequences]. Also, compare Wolfram Code principles to my discussion of binary numbers, especially regarding their mirror and complementary forms. The speed of change can range from no cell changes per step up to one cell per step (every cell changes on a step). He translates these rules into instructions for the computer to print out visually the steps in two colors (black and white). In later sets of rules he uses three colors (black, white, grey) and various other modifications of increasing complexity. With three colors the number of possibilities goes from 256 to well over seven trillion.

**Relaxation of Bias**

The principle of relaxation of bias at fine resolutions explains the "quantum leap" and strange phenomena such as the double slit experiment. When a system's bias (boundary) relaxes, its "attention" becomes de-localized. When you go to sleep tonight, pay attention to the process by which your attention de-localizes. Then notice how it re-localizes when you wake up. Try deliberately de-localizing your attention. For example, imagine yourself being vastly bigger than the whole universe, such that the universe is not even noticeable. You get homogeneity. Imagine that you do not exist as an individual, and your will has completely gone to sleep. Stuff just comes and goes willy-nilly. You may get an increase in randomness. Understanding how attention works explains a great deal of the mysteries of quantum mechanics.

According to Heisenberg, as the ($\Delta x$) gets to finer resolution, the ($\Delta p$) gets de-localized. When the ($\Delta p$) gets to fine resolution, the ($\Delta x$) gets de-localized. When the TM mantra ($\Delta x$) gets really, really subtle, the "momentum" of consciousness expands to fill the whole universe. We experience unbounded awareness and then any thought can come up. The attention is not biased toward preferring certain thoughts.

When the momentum of a photon beam is very precisely confined, its position becomes very non-local. The photon beam goes through a tiny aperture (focused direction) and then ends up spraying photons all over the place (a symptom of unfocused location). Heisenberg's relation says

* $(\Delta p)\ (\Delta x) \geq \hbar$.

The $\geq$ operator means that both position and momentum intervals can relax their bias and expand, which they do, if given half a chance. Thus, in the double-slit experiment, you get a single photon generating interference with itself as if it goes through both slits -- which it does -- IF you relax the bias that it MUST hold to one path. If you tighten the bias by closing either slit or by trying to measure the photon as it goes by (i.e. monitoring), then you lose the unbiased interference pattern.

The tiny aperture experiment is microscopic and invokes the Heisenberg relation. The double-slit is macroscopic and just involves the range of relaxation of the boundaries of attention focus. Attention's conjugate partner is a photon. We only perceive photons. Everything else is imaginary. Photons are by nature non-local, but we squeeze their beams (pop qwiffs) by the focus of our attention beams. Scientists puzzle over quantum mechanics because they do not want to take responsibility for their own consciousness. However unfocused your attention is, the photon wave function will meet you at that level of focus. You can only see what you are looking for/at. All the rest is imaginary. If you have three slits, you'll get three waves interfering. Unless, of course,....

Perhaps the most important insight Wolfram is promoting in his book is something that he gained from working on his **Mathematica** project. Over the past three hundred years mathematics has undergone a process of evolution that resulted in the "liberation" of mathematics -- the realization that all mathematics is an arbitrary game designed by the mathematician. (See Hockett's design feature of "arbitrariness".) Liberated Math is what I call "Observer Math" (OM). Anything goes as long as you are reasonably consistent and have fun. (I suppose the fun part is optional.) Gödel's technique is a good example of using a really imaginative method to do mathematics. Wolfram has seen that this notion of liberation transfers to physics and other disciplines of science as well. He realizes that there is no "right" way to do physics, and physics then becomes an unbounded field to play in. In a nutshell Wolfram has realized (**A New Kind of Science**, p. 5) the principle of Observer Physics that the rules of science can be "rules of essentially any type whatsoever." This is the liberation of science -- something which thoughtful scientists have been aware of for some time, but have not dared to trumpet loudly because of the general population's addiction to the "reality" of reality according to their pet beliefs.

In Chapter 4 of his book Wolfram plays with operations on numbers as automata programs that generate various waveforms. Compare his findings with the ideas presented in the first several chapters of **OP**. In other chapters he considers (5) multidimensionality, (6) randomness as a starting point, (7) the relation between programs and nature, (8) the everyday world, (9) physics, (10) perception and analysis, (11) the idea of computation, and (12) his principle of computational equivalence. He finds that the same types appear wherever he looks, and decides that they are universal types.

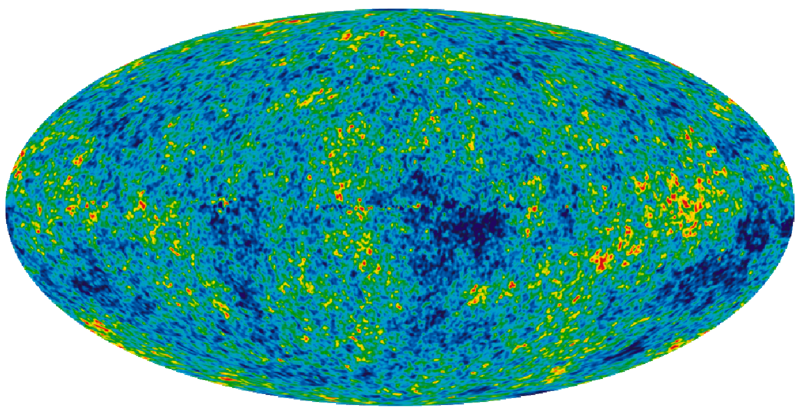
His chapter on physics is particularly relevant to observer physics. Here are a few key points that come up.

* He notes that principles such as conservation of energy and equivalence of directions seem unrelated to the behavior of cellular automata but can be mimicked by certain programs. This suggests that they are special cases within a much larger and more general context. The same is true of reversibility. Many automata are irreversible. Our previous discussions of pathways explain why.

* Wolfram notices that lots of automata do not seem to follow the second law of thermodynamics. It should be clear why. He is confusing the Mind Space and the

World Space. Automata belong to the Mind Space, even though they can be run on a computer. If they are precise and discrete sets of rules and operations with predictable behavior, it is possible to extend them with certainty as far as you like with no loss of information. The second law describes the World Space. Wolfram's paper printouts are subject to the second law, but not his pure mathematical algorithms. This is a key point of **Observer Physics** discussed in chapter 1. Confusion results when we lose track of where we as observers stand *vis-a-vis* the crossover points in a system. Wolfram's real insight here occurs when he turns the situation around and realizes that the second law may be a biased viewpoint that only looks at a select range of possibilities. In other words, the second law may not be as general as many people assume.

* On page 455 Wolfram comments that the darkness of the night sky is evidence for the expansion of the universe. In fact this is only evidence supporting the belief that the universe is expanding. By shifting viewpoint one easily notices that there is background radiation everywhere.



**Wikipedia**, “Cosmic Background Radiation”

The apparent extreme red shifting of this radiation beyond our visual range may be interpreted as merely a sign of the observer's incredible shrinking viewpoint. As an experiment go out on a clear night and observe the sky. Gently adjust your viewpoint until you can actually perceive that the sky is filled with light. Go back inside and close the door, turn off the lights, and, if you like, put your head under a blanket or go into a closet and close the door. (Alternatively you can get a sensory deprivation tank and really do some experiments.) Tune your vision until you can see the light field that persists even when all "external" lights are extinguished or blocked. Where does that light field come from? What do you believe?

* Wolfram believes (p. 468) it will not be possible to find the Great Rule that generates the universe without already knowing it. Well, then he should already know it. Palmer's Theorem (you only experience what you truly believe), the Fundamental Principle of Observer Physics, states it very simply and clearly with a self-referring fractal formula that automatically generates the universe, or any other universe you might like to explore. **Observer Physics** is a start at unfolding some of the consequences of that principle and showing how it links up to what we already know (strongly believe) about modern physics.

* Wolfram believes that the nature of space-time is a huge nodal network. This is a very interesting idea and worth exploring in the light of other emerging theories such as Nottale's fractal space-time (that I discuss below) and the notions of Observer Physics. In an aside, however, Wolfram notes (p. 476) that there are really only networks of 0-, 1-, 2-, and 3-branch nodes. The 0-branch ones are of course null networks -- that is, nodal dusts. No interactions happen with 1-branch nodes either. Two-branch systems seem trivial. All others are just 3-branch nodes or combinations of 3-branch nodes. Feynman diagrams for QED show only 3-branch nodes: 2 for electrons and one for a photon (pair). In observer physics we show that the QED Feynman diagrams are really 4-branch systems. Any QED interaction is really a four-wave/four-particle mixing involving, say, two electrons and two photons. The photons have tight trajectories that are read as one. The rule about 3 branching nodes forces the interaction into a ring or bubble structure. This is an example of a phase conjugation quantum bubble. Such a bubble can be of any size. It generates the illusion of space-time. Within the bubble is a region of hyper-space-time. Interactions occur within that bubble at the Planck Velocity. An observer can choose to operate outside the bubble, or inside the bubble, or on the boundary, or as the whole system, . . . . A complete QED interaction involves two linked conjugate 4-branched nodes: for example, two electrons to two photons and then the two photons to two electrons; or a pair of photons to an electron-positron pair and back to a pair of photons.

* It is interesting to compare Wolfram's model of relativistic time dilation (pp. 523-524) with the klystron models we discuss in **OP**. One might also compare his automaton models of elementary particles (pp. 525-530) with the **OP** models built from decimals and with the self-regenerating dynamic lepto-quark models of **OP**.

In spite of a few minor criticisms, I enjoy this book very much. It is an excellent (probably the classic) reference work on cellular automata, and a landmark in the evolution of the New Kind of Science. Wolfram definitely deserves his "genius award." He's doing excellent work except for his weak definition of randomness.

**Another Step: Laurent Nottale's Theory of Scale Relativity**

Although it is clear that the physical world is not perfectly fractal in structure, Nottale has made some strides toward what I call a pseudo-fractal theory of Scale Relativity. Below are some comments on his work **Fractal Space-Time in Microphysics: Towards a Theory of Scale Relativity.**

**Chapter 1: "General Introduction."**

Nottale presents his general hypothesis that addresses the problem of scaling and scale invariance and gives a brief summary of the topics to be covered in his discourse.

**Chapter 2: "Relativity and Quantum Physics."**

Notalle gives a summary of the present state of physics, pointing out the lack of theories to predict at the smallest and largest length and time scales. He also points out the divergences (infinities) that crop up in both classical and quantum models and the inadequacy of renormalization techniques to deal with the problem. He points out the circularity of Einstein's notion that gravitation is space-time curvature. What is the curvature there for? Is it to produce gravitation? He mentions the curious correspondence of a complex operator with a real momentum. What's that doing there? Where is it? What is quantum foam? The Riemannian geometry of relativity fails to handle the quantum world. New concepts are needed to extend "Relativity". He defines the three forms of relativity involved in "locating" an event: (1) a **ratio** to axes with an origin; (2) a **unit** of measurement; and (3) a **resolution** that indicates the "precision" of a measuring method (i.e., a limitation of some kind). In Observer Physics we discuss these three relativities as the **ratio**, the **unit**, and the **scale** of a constant or other physical measurement. For example,

* $c = 3\times10^8$ m/s.

Here 3 is the ratio, m/s is the defined unit, and $10^8$ is the scale. These three relativities are all set by the observer. Units are necessary for any measurement because all measurement is a comparison of two relative phenomena. Notalle opts to retain the space-time continuum hypothesis while adding the notion of fractal structure to space-time, something that Feynman discovered in developing QED (though the term “fractal” was coined later by Mandelbrot). He also points out that in quantum physics there appears to be limiting scale that is "invariant under dilatation" (p. 26) and corresponds to the role of $c$ for the laws of motion. Like $c$ it is not a "cut-off", or a "quantization" or a "discontinuity". He considers the de Broglie length and time to be the “characteristic transition scale occurring in the quantum phase” (p. 14). Nottale points to the universality of the Heisenberg inequality as fundamental to the problem of resolution and scale. The notions of Planck length and time are now being extended from the quantum micro-scale toward a theory of quantum gravity, perhaps not merely relevant to the very early universe. We must give up Minkowskian space-time and find a new space-time model that fits both relativity and quantum mechanics. Notalle posits a "zoom dimension" and "zoom space-time" using ($\Delta t$, $\Delta x$, $\Delta y$, $\Delta z$) alongside the usual ($t$, $x$, $y$, $z$). These $\Delta x$'s and so on correspond to the "peanut" or "gap" numbers that we introduce in **Observer Physics** and provide the resolution at which an event is viewed by an observer, while at the same time ensuring continuity. The observer defines the exact size of a $\Delta x$. Notalle uses little "balls" to smooth out the fractal curves into approximations with finite lengths and measurable slopes. The fractals are inherently infinite in length and have undefined slopes -- which render them non-differentiable. This "ball technique" is similar to the Snow White and Seven Dwarfs quantum foam approach we adopt in chapter 13 with the circles and spheres forming the “balls”. In observer physics we have located the meter unit $R$ as the constant component that (along with $pi$, $c$, and $e$) defines the fundamental mass unit of atoms – the proton – and thus lies at the foundation of the physical universe. We also identify % as a scaling constant that works together with $R$.

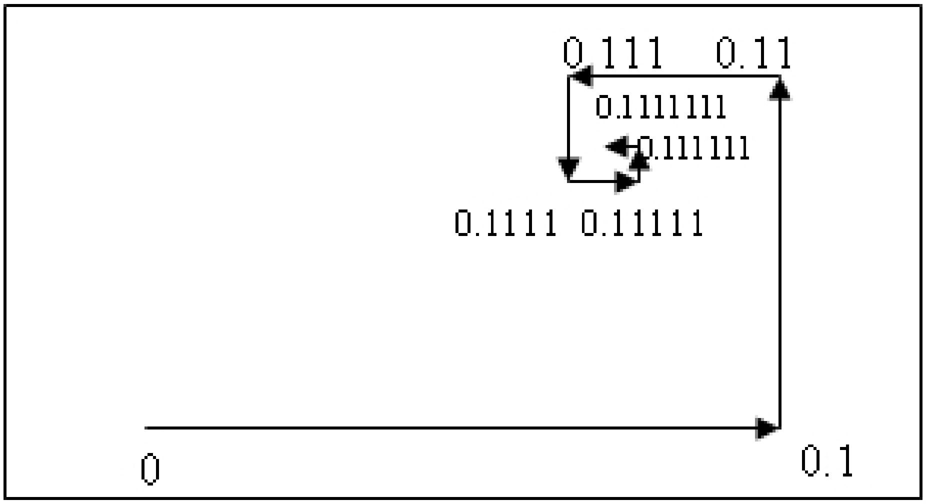
**Chapter 3: "From Fractal Objects to Fractal Spaces".**

In this chapter Notalle introduces in detail the concept of fractals, providing examples of fractal objects that have topological "dimension $D_T$ and fractal dimension $D$, such that

$D>D_T$" (p. 33). The discovery that fractal structures occur commonly in nature brings up the desire to explain why they occur in nature. Notalle suggests that fractal geometry is a generalization of the ordinary Euclidean and non-Euclidean geometries that unfold in whole number dimensions. If it turns out that fractal structures dominate over non-fractal structures in nature, then the use of differential calculus may require essential revision. Fractals exhibit the paradoxical condition of “scale divergence” (e.g., the length of a fractal curve or area of a surface “tends to the infinite when resolution tends to zero” [p.34]) combined with boundedness (e.g., you can have a curve in a plane with infinite length and infinitesimal area or an infinite surface in a space with infinitesimal volume [p. 40]). Self-similarity allows a fractal to remain identical locally after undergoing dilation or contraction. Notalle refers to this as "a periodic system in the 'zoom' dimension." (p. 40) He also notices that the renormalization group approach in QED, for example, starts from the infinitesimal and works upward to larger scales with patterns of self-similarity, whereas fractals are usually generated from a macroscopic generator that is then iterated at increasingly smaller scales. He suggests that these might be conjugate forms -- that is, inverse transformations. In observer physics we discuss entropy (kinetic energy) and gravity as inverse transformations that scale in space.

Notalle describes the basic role of fractals in Nature as an optimization process under constraint or contradictory conditions such that the system comes back to the previous state, but at a smaller (or possibly larger) scale. He gives the example of self-similar invagination to increase a surface of exchange within a constrained space.

Notalle develops the mathematical description of fractals and points out that fractals are usually envisioned as embedded in Euclidean space. He proposes that if fractal structures dominate over integer structures, perhaps we should consider moving beyond the idea of embedding in a Euclidean space to a fundamentally fractal space-time and give up the notion that the curvature of space-time approaches Euclidean space as a micro-scale limit. In fractal space a trajectory's curvature approaches infinity as $\Delta x$ approaches zero. Of particular interest in this chapter is Notalle's discussion (section 3.4) of NSA (non-standard analysis) and the Robinson hyper-reals (supersets $*R$ of $R$ that include infinites and infinitesimals) as tools for developing notions of a fractal derivative and fractal integrals. This leads to reformulating the Cauchy-Weierstrass limit used to define the calculus. (See **Observer Physics**, chapter 1.) Notalle shows a sample fractal curve representing the number 0.11111.... (p. 60). Each succeeding digit of the decimal encodes a 90-degree dimensional shift and vector with a constantly reduced scale. This gives a fractal curve in the shape of an infinite spiral.




Drawing based on Notalle, Fig. 3.11

From this example it is clear that we can reinterpret all the infinite decimals that we play with in **Observer Physics** as fractals. Numbers such as 0.1111... take on unique interpretations. The number 1.000... is definitely not the same as 0.11111… -- if we view it as a fractal. Using NSA techniques Notalle can extract finite solutions (approximations) from non-standard differentiation of fractal curves. He also considers fractal functions, variable fractal dimensions (e.g. curves that tend from $D = 1$ to $D = 2$ as they go along or curves that vary their level of resolution) and leads us toward a definition of fractal space-time. He defines a fractal space as "the equivalence class of a family of Riemann spaces characterized by a family of Riemann tensors $R_{ijkl}(\varepsilon)$" (p. 86).

**Chapter 4: "Fractal Dimension of a Quantum Path".**

In this chapter Notalle begins to apply his ideas to the foundations of physics. He begins with Feynman's discovery that quantum trajectories are fractal. Each quantum path is equi-probable, but its "probability amplitude" has only a phase term. So from the view of "infinite precision" all paths are equi-probable, but when viewed from an arbitrary resolution, paths divergent from the classical path cancel out. Paths very close to the classical path are wiggly and fractal. The transition from quantum fractal behavior to classical non-fractal behavior occurs, Notalle proposes, at the de Broglie scale (p. 91). Quantum systems are characterized, he believes, by $D = 2$. (He gives as a rough example the orbitals of a hydrogen atom.) Classical systems exhibit $D = 1$. The jump from fractal to classical occurs at the de Broglie length:

* $\lambda_{dB} = \hbar / p$.

He translates the Heisenberg relation in terms of fractals: "The fractal dimension of a particle's trajectory jumps from D=1 to D=2 when the resolution becomes smaller than its de Broglie length." (p 95). Notalle sees this as a quantum relativistic path. He plots a doubly relativistic (scale and motion) diagram (p. 100) to show two transitions -- a spatial coordinate transition at the de Broglie length as $\Delta x$ increases, and a temporal coordinate transition at the de Broglie time as $\Delta t$ increases. So the quantum relativistic dimensions are $D = 2$ for both space and time. In the quantum domain time becomes $D$

= 1 until it reaches the quantum relativistic range. In the classical domain, both space and time are $D$ = 1. Notalle refers to the fundamental phenomenon that in the relativistic domain particle-pair creation-annihilation occurs. Measuring at the precision of

* $\Delta x = \hbar / m\, c$

in the particle's rest frame puts the uncertainty on the threshold of pair creation. The limit for position is

* $\Delta x = \hbar\, c / E.$

In observer physics we identify the ratio % as the ratio of $\hbar\, c$ and place that as the spatial interval for the minimal pair-creation threshold:

* $m_{ve} = \hbar / c$ %.

At this energy level, light waves can begin to manifest as neutrinos. Nottale stresses the loss of precision with regard to position $\Delta x$ when we are dealing with quantum particles. This is particularly obvious with neutrinos, the lightest particles.

Notalle suggests that non-relativistic quantum time may take the form of a fractal dust with a fractal dimension of 1/2 and a topological dimension of 0.

The jittery quantum trajectories (Zitterbewegung) of quantum particles indicate folding in time and virtual pair production. He interprets these as fractal space-time. Fractal space-time defines quantum particles in the same way that curvature defines gravitation in Einstein space-time.

**Chapter 5: "The Fractal Structure of Quantum Space-Time."**
In this chapter Nottale goes on to develop his idea that fractal space-time defines quantum particles in the same way that for Einstein space-time curvature defines gravitation. The particle becomes its own trajectory and is thus just a manifestation of fractal geometry.

Nottale mentions a Peano curve that, depending on the angle one views it from, either has a "constant" slope of 0 or a periodic slope that flips back and forth between 1 and -1. He suggests this as a model for shifting from quantum interference to classical wave structure. He develops a fractal picture of how a measurement may affect a fractal trajectory causing unpredictable results. He shows how uniformity appears only at the ideal fractal level and disappears when approximations are made at various resolutions. He also develops the way in which a fractal trajectory may resemble a probabilistic distribution.

He discusses the problem with velocity and the speed of light in microphysics and shows how it varies with regard to the scale of resolution. Then he brings up the problem of electron quantum spin. The speed at the surface of the electron would seem to exceed light speed. He suggests that certain types of fractal may satisfy the observed spin phenomena with quantum particles. Another idea he presents is that Gödel's theorem applies not only to mathematics, but to physics. Quantum physics, he believes, is encountering the same occurrence of non-demonstrable, but true, situations that mathematics does.

When he discusses the deeper issues of the EPR problem, randomness, stochastic quantum mechanics, and the role of Brownian motion, there is a sense that he is begging the question. We do not know where the randomness comes from. However he does make the cogent point that relativity of motion should be extendable to include non-differentiable states and thus include fractal dimensions. He would like quantum mechanics to achieve Einstein's goal of derivation from "fundamental principles" (p. 136), but, like Milgrom's MOND formula that lacks a principle, Nottale sees that the current QM stochastic processes still fall far short of that mark (p. 137). Nottale attempts to go further with his postulate of a fundamentally fractal space-time, but admits that he still falls short of Einstein's ideal (p. 143).

Nottale discusses at length in section 5.7 the transition between quantum and classical dynamics. He believes that the transition is reversible and defined by the thermal de Broglie wavelength ($\lambda_t$):

* $\lambda_t = \hbar / (2\, m_x\, k\, T)^{1/2}$.

Here $m_x$ is the particle's mass, $k$ is Boltzmann's constant, and $T$ is the absolute temperature (Kelvin). Oddly enough, a Brownian motion can push a system from quantum to classical or vice versa. Although this "explains" how a motionless ($v_x = 0$) macroscopic object can have precise position, but infinite de Broglie length ($\hbar / m_x\, v_x$), it does not explain where the thermal (or Brownian) energy comes from. Nevertheless, Nottale claims that the fractal approach provides "information about the virtual internal structure" (p. 159) of a particle's trajectory.

In section 5.9 Nottale shows how QED Feynman diagrams are really fractal structures and in 5.10 he discusses the anomalous heavy ion collisions as possibly following fractal patterns. He suggests that current models of quantum mechanics may require revision under new findings from strong field experiments (such as the anomalous Darmstadt heavy ion collision findings) and at the very small (high-energy) scale.

In 5.11 he begins his discussion of General Relativity to develop his theory of Scale Relativity. He notes the problem that when a mass gets beyond the Planck mass, its Compton length gets below the Schwarzschild radius. We can not measure such a length because it is inside a black hole. On the other hand the Schwarzschild radius lacks physical meaning below the Planck mass. This leads him to his major point that the Planck length is an un-passable lower limit somewhat like the speed of light $c$, and thus forms a universal constant. On p. 188 he has a chart of the Compton length

* $\lambda_c = (\hbar / m_x c)$

and the Schwarzschild radius

* $r = (2 G m_x / c^2)$

plotted in terms of ($\ln m_x$) versus ($\ln r$). He proposes that, as the two relations approach the Planck length, they curve asymptotically. In **Observer Physics** we not only propose the Planck length as a minimum scale, we show how it generates our human scale lengths of $R$ = 1 meter and % = 3.1622 meters via the Heisenberg relation in a fractal manner. This defines the relation between the Joule and the D-Shift Gauge and the Planck scale.

* $[10^{-26} (\mathrm{J} / c)] (\%) = \hbar$.
* $\hbar c / [(\pi\%^2 / \mathrm{Ao})^{-26} (\%) = 1$ J.

The D-Shift Gauge is a major tool for shifting scale in quantum mechanics. It will be very helpful to Notalle in refining his theory.

In section 5.11 Nottale goes right in for a close look at the Planck mass (pp. 187-190), and then shows how relativity and quantum mechanics both need some fixing. He does what we do in **Observer Physics** -- he looks at the Planck mass, Compton length, and Schwarzschild radius. What he sees is a critical point, a barrier where physics breaks down. In **Observer Physics** we see this situation as the window of opportunity to a new physics. Notalle, from his fractal angle, has the same hunch. He then brings up what is basically the Millikan experiment -- he notes that "the gravitational force between two Planck masses is the same as the Coulomb force between two bodies each of them carrying (about) 12 elementary electric charges." The "12" here is actually due to the fact that Nottale left out the fine structure constant when he considered the two masses, because he was figuring from the traditional value of the Planck mass. But he definitely got close to seeing the picture.

* $M_P = (\hbar c / G)^{1/2}$.

Having come from first calculating the equilibrium of gravity and the Coulomb force, we arrive at a figure that differs only by the fine structure constant, but neatly unifies these two viewpoints of gravity and electricity and connecting it to the Planck mass.

* $B_u = (\hbar c a / G)^{1/2}$.

When we take the square root of $a = 137^{-1}$, we get approximately (1 / 12) and a particle size that exactly balances a **single quantum of electric charge**. This becomes clear when you calculate the balance point between gravity and the Coulomb force and look at it together with the Planck mass, Compton length, and Schwarzschild radius calculation. Here's the whole story in a nutshell (See **Observer Physics**, Chapter 12.) leading to the relation between quantum charge, the Planck scale, and light speed.

The fine structure constant ($a$) comes up as the coupling constant when the Planck mass self-interacts to form a pair of Union Bosons. This pair finds equilibrium as the proton ensemble and becomes a persistent mass. Each time the proton iterates, $a$ gets squared. If it can't find equilibrium as a Boson pair, the Planck mass is a virtual particle that self-annihilates by Hawking radiation. These entities clearly have fractal or at least quasi-fractal structures. Here Nottale again is definitely on the right track and gets very close to seeing how it works. He even suggests some experiments that could be done studying the gravitational interactions of dust grains. Such experiments are quite recommendable. (See diagrams of the Planck mass fractal structure at end of this review.)

**Chapter 6: "Towards a Special Theory of Scale Relativity"**

Having established his notion of an "unpassable lower scale to Nature" as a natural unit for scales, Nottale begins developing his theory of scale relativity. His absolute and universal scale is independent of any particular physical object and based only on the three physical constants $\hbar$, $c$, and $G$.

* $\lambda_P = (\hbar\, G / c^3)^{1/2}$.

One principle that immediately emerges is that the scale relativity is not an ideal fractal form, because it has a lower limit at the Planck length and it breaks at the de Broglie transition. Another principle that emerges is that laws of scale replace laws of motion under high-energy conditions (p. 196). This is similar to the way that time and space switch roles on either side of $c$.

Nottale first reviews the successes and tricks (e.g. renormalization) used in QED and the GUT theories. Then he points out many discrepancies that have emerged and the *ad hoc* nature of many fixes. He points out that both measurements and numbers require scales, and we should find the most fundamental and universal scale as our master scale. He proposes the Planck scale. Relativity finds a dimensionless value comparing a relative scale to an absolute scale ($v / c$) and $(1 - (v^2 / c^2))^{1/2}$, based on Einstein's principle of the limit $c$. This seems to be the direction Nottale is moving to find solutions to physics problems based on his scale relativity principle with its fixed Planck length.

Nottale discovers in 6.5 that his laws of scale transformation follow a Lorentzian form, not a Galilean form. In 6.9 he develops "Generalized de Broglie and Compton Relations", "Generalized Heisenberg relations", and a "Transformation of Probabilities". Then in 6.10 he looks at the "Implications for High Energy Physics", considering the divergences of mass and charge and making some predictions.

On p. 258 he is drawn back to marvel that, within a factor of 2 (by his calculations):

* $\lambda_P = \hbar / m_P\, c = G\, m_P / c^2$.
* $m_P = (\hbar\, c / G)^{1/2}$.

As mentioned above, in the beginning of Chapter 12 of **Observer Physics** we discuss this remarkable situation in some detail.

In 6.11 Nottale derives some interesting formulas for the masses of the intermediate vector bosons in which he connects them to the Planck scale and to the electron scale.

Toward the end of Chapter 6 (p. 276) Nottale again gets hot on the trail with his notion that charge is what he calls "fundamental dilatation". In **Observer Physics** (Chapter 10) we discover what this "fundamental dilatation" really consists of and how it is generated when we discuss the question of electric charge.

**Chapter 7. "Prospects**."
In this final chapter Notalle opens up his principle of scale relativity to look at cosmology and the large-scale vision of the universe. This chapter is far ranging and much more speculative than the earlier chapters. He begins by considering the curious ability to express the electron mass in terms of the Hubble constant ($H_o \approx 3\times10^{-18}\ \mathrm{s}^{-1}$) that measures the expansion rate of the universe, a coincidence that many have noticed.

* $(\hbar^2 H_o / G c)^{1/3} \approx m_e a^{-1}$.

But what do you do with that? The Hubble "constant" changes over time. Does the electron mass then change too, . . . or $\hbar$, or $G$, or $c$, or $a$?

Nottale plays with a revival of Mach's Principle. He notes that this principle makes the universe into a black hole. Following Sciama he mentions the idea of gravitational induction on the analogy of electromagnetism. He considers masses compared to the mass of the universe and compared to the Planck mass. For example, using his Planck scale principle, Nottale suggests that Newton's second law could be rewritten as:

* $F = \hbar c [(m_x) / m_{\mathrm{P}}) (m_y / m_{\mathrm{P}}) / r^2]$.

Nottale starts the Big Bang clock at the Planck time, not at zero time. He notes that causally disconnected parts of the universe should act independently, but strangely the background radiation is quite even. He feels the inflationary theories are *ad hoc*. He proposes that scale relativity changes the behavior of light cones, causing them to flare wider in the primeval universe. Thus he resolves the strangeness issue without resorting to (or perhaps we should say in a manner that looks equivalent to) inflation. This means that at the resolution of Planck time all points of the universe are causally connected. (See his excellent chart on p. 293.) I agree with this conjecture for reasons that involve the role of the Observer, a factor that Nottale, for all his creative ideas, insists on ignoring.

Further on (p. 296) he brings up Laplace's wonderful remark that Newton's law of gravity, when scaled, reproduces the universe at any scale. That is -- it is **scale invariant**, as we also noticed with the electro-gravity equilibrium. Nottale goes on to mention the dispersion relation for objects in a gravity field, mentioning that a gigantic galaxy rotating relative to itself is static.

* $G\,m = \langle v \rangle^2\, l$.
* $l = G\,m / \langle v \rangle^2$.

He takes this as a macro-scale version of the micro-scale de Broglie length:

* $\lambda_{dB} = \hbar / m\,v$.

To get these to be equal, you discover:

* $m = (\hbar\, v / G)^{1/2} = m_P\,(v / c)^{1/2} = m_P$

He points out that, if $v = c$, then $m$ becomes the Planck Mass, ($m_P$). This connects the two domains at the microphysical level (p. 297.)

He looks at the vacuum energy density $\rho_P$. In standard QM this diverges. By setting the Planck scale limit Nottale gets:

* $\rho_P = (c^5 / \hbar\, G^2)$.

Later (p. 301) Nottale comments that the "Universe at its own resolution" is invariant under dilation. He suggests the Einstein spherical model as this viewpoint, with local variations. This leads him to his ratio of the mass of the universe $M_U$ to the Planck mass.

* $M_U / m_P = \pi\, K_U / 2$.

Here he estimates the value of $M_U$ to be $10^{53}$ kg, or $10^{23}$ solar masses, or $10^{11}$ galaxies with an average of $10^{12}$ solar masses each. Nottale suggests carrying Mach's Principle to the point of connecting the masses of elementary particles to the mass of the universe after the fashion of the Hubble constant coincidence. By analogy with his lower limit Planck length $\lambda_P$ he posits an upper limit $\lambda_U$. You can't get beyond it, even with the universe expanding. This length scale stands in for infinity. He suggests a ratio $K_U$ between these two lengths (p. 299).

* $K_U = \lambda_U / \lambda_P$.

He relates this to the cosmological constant ($\lambda_{cc}$).

* $(\lambda_U)(\lambda_{cc})^{1/2} = 1$.

From this he estimates the value of $K_U$ to be around $10^{61}$.

He identifies the smallest possible energy as

* $E_{min} = \hbar\, c / \lambda_U$.

* $m_P = (\hbar\, c / G)^{1/2} = 2.176\times10^{-8}$ kg.
* $a\, m_P / m_e = K_U{}^{1/3} = 1.7437\times10^{20}$.
* $K_U = 5.3018\times10^{60}$

Nottale again comes in really close with his conjecture. He defines a scale $r_o$

* $r_o = a\, \lambda_C = (a\, \hbar / m_e\, c)$.

This is the Lorentz electron radius, with $a$ equaling the fine structure constant and $\lambda_C$ as the Compton length for the electron.

He considers the electron as purely electromagnetic, putting it in terms of $e$. In our notation we would write Nottale's expression:

* $e^2 / 4\, \pi\, \varepsilon_o = (m_e\, c^2)\, (r_o)$.

Substituting the value of $r_o$ and then the value of $a$ in constants, we get:

* $e^2 / 4\, \pi\, \varepsilon_o = (m_e\, c^2)\, (a\, \hbar / m_e\, c)$.
* $e^2 / 4\, \pi\, \varepsilon_o = \hbar\, c\, a$.
* $a = e^2 / 4\, \pi\, \varepsilon_o\, \hbar\, c$.

Then Nottale puts the electron's "gravitational self-energy" at the $r_o$ scale at his minimal energy $(\hbar\, c / \lambda_U)$.

* $G\, m_e{}^2\, (r_o) / (r_o) = (G\, m_e{}^3 / a^3)\, (c / \hbar) = \hbar\, c / \lambda_U$.
* $(m_e / a)^3 = \hbar^2 / G\, \lambda_U$.
* $(m_e / a)^3 \quad \hbar^2 / G\, \lambda_U\, \lambda_P\, K_U$.
* $\lambda_P = (\hbar\, G / c^3)^{1/2}$.
* $K_U = (a / m_e)^3\, [\hbar^{4/2})\, \mathrm{G}^{(-2/2)}\, (\hbar\, G / c^3)^{-1/2}]$.
* $K_U = (a / m_e)^3\, \hbar^{3/2}\, c^3/2\, G^{-3/2} = (a\, m_P / m_e)^3$.
* $(a\, m_P / m_e) = K_U{}^{1/3}$.

What is remarkable here is how close Nottale comes to the simple figures for the Union Boson. He does not have to make all those assumptions. Or, conversely, we can say that the calculations of **Observer Physics** provide a simple way to support his assumptions as basically correct.

* $B_u = (\hbar\, c\, a / G)^{1/2}$.

We simply reorganize the details of his calculation and the Union Boson magically appears -- almost.

* $K_U = (a / m_e)^3\, [\hbar^{4/2})\, \mathrm{G}^{(-2/2)}\, (\hbar\, G / c^3)^{-1/2}]$.
* $K_U = (\hbar\, c / G)^{3/2}\, (a / m_e)^3$.
* $K_U = (\hbar\, c\, a / G)^{3/2}\, (a / m_e{}^2)^{3/2}$.

* $[(\hbar\, c\, a\, /\, G)^{3/2}]\, (a^{3/2})\, /\, m_e^{\,3} = (a^{3/2})\, (B_u^{\,3} /\, m_e^{\,3}) = K_U.$
* $(a^{1/2})\, (B_u\, /\, m_e) = K_U^{\ 1/3}.$

Here again is that factor of $a^{1/2}$ or about 1/12 that Nottale was off by in his other calculation where he looked at the Planck mass, the electrical force and gravity. So I would suggest that the proper equation simply may turn out to be:

* $B_u\, /\, m_e = K_U^{\ 1/3}.$

This boosts the value of $K_U$ up to around $8.5\times10^{63}$.

The closeness of Nottale's findings to our findings in **Observer Physics** suggests that there is much interesting research to do in this area.

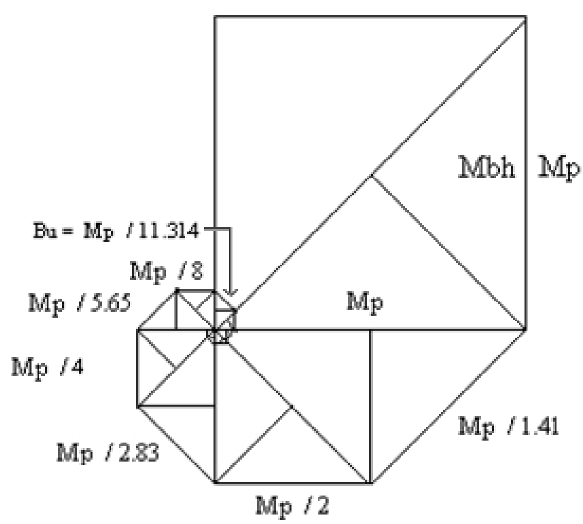
Nottale mentions the problem of global uniformity not squaring with his fractal idea at the cosmic scale and admits the tentative nature of his conjectures.

In 7.2 he goes "Beyond Chaos", considering some other speculative notions such as "prediction beyond predictability", an interesting fractal model of the solar system, and the use of fractal models for studying chaotic systems.

The strong evidence uncovered in **Observer Physics** of ratios that echo in a fractal-like manner at various scales throughout the relationships of the physical constants suggests that Nottale's theory is moving in the right direction. More emphasis on the critical role of the observer in physical events may be helpful.

In summary, I consider that Nottale's book is well worth careful study.

**The Quasi-Fractal Structure of the Planck Mass**




Going from the Planck Mass into the Quantum Source Realm;
Mp is Planck Mass, Mbh is black hole mass, Bu is Union Boson.

That the above diagram does not exactly match the physics, is probably due to distortions from pressing a 3-space event into a flat diagram. Nevertheless, we are going to use this drawing as a guide to discover one of the great secrets of the fine structure constant, $\alpha$, and perhaps much more. The diagonal of the large square is set at 1 and represents the Planck Mass, $M_P = \sqrt{(\hbar c/G)}$. The side of the largest square represents $\hbar$ and has the ratio of 1.054, which is a slightly distorted version of 1. Planck's constant has the units of angular momentum, and together with $c$ these two constants gives us Kepler's dynamics ($m^3/s^2$) for an object with mass. Dividing out the units of $G$ gives us Kepler's dynamics exactly canceled while bringing a second particle with mass into the relation. The two particles coexist forever as two "quarks" stuck in a black hole relationship that generates a stable hadron known as the neutron/proton complex.

| | |
|---|---|
| Largest square side | $= M_P/1$ |
| Side of square #2 | $= M_P/1.41421356237$ |
| Side of square #3 | $= M_P/2$ |
| Side of square #4 | $= M_P/2.82842712474$ |
| Side of square #5 | $= M_P/4$ |
| Side of square #6 | $= M_P/5.65685424948$ |
| Side of square #7 | $= M_P/8$ |
| Side of square #8 | $= M_P/11.3137084989$ |
| Side of square #9 | $= M_P/16$ |

. . . . . . . . . . . . . . . . . . . . . . . . . .

The 9th square's side $M_P/16$ lies on the largest square's side ($M_P/1$) and is 1/16th of its length. I suspect that this may be the source of the quantum electric charge, $1.602\times10^{-19}$ C (or kg/s). The rotation as the "squares" unfold generates the magnetic charge as an axial pole in the lower left hand corner of the largest square, the location of Source. The 8th square's side lies with its diagonal on the $M_P/1$ square's diagonal and is 1/11.3137th of its length. That is very close to the square root of the fine structure constant ($\alpha$), a ratio that tells us the difference between the "standard" Planck Mass and the $B_u$ particle and gives us electro-gravity equilibrium. As the nautilus-like quasi-fractal spiral goes to smaller scales, there is a warp to it that you can't see in this flat projection. The average scaling factor comes out to a tad over 1.421, which is just slightly above $2^{1/2}$: (1.4142121356237/2.421 = 0.99522418182. This gives the following scaling dimensions adjusted approximately to the physics:

* **Mp = Mbh; Mp / 1.421** ≈ **1**, Mp / 2.019241, Mp / 2.86934, Mp / 4.077, Mp / 5.79, Mp / 8.233, **Mp / 11.7 = Bu**.
* $Mp = (\hbar\ c / G)^{1/2} = 2.17651(13)\times10^{-8}$ kg
* $Bu \approx Mp / (11.7) \approx Mp / (1.421)^7 \approx 1.86)\times10^{-9}$ kg.

From $M_P/1$ down to $Bu = M_P/11.314$ we take 7 steps, dividing by seven powers of 1.421. The Schwarzschild radius is the radius of a non-rotating sphere from which, if all the mass is inside the sphere defined by the square, the escape velocity at the radius equals the speed of light, hence presumably producing a black hole Mbh at $M_P/1$ that serves as a third quark and spits out neutron/protons. Once the unwinding spiral reaches the Mbh outer limit (event horizon), the energy radiates at light speed unwinding the spiral. The process continues doubling the Planck Mass and begins spewing out particles and antiparticles. This unwinding may account for the era of inflation. The spiraling fractal expansion is just like the contraction reversed and doubles in side length with each 90º turn. The area goes up as the square of each side. Presumably the volume goes up as the cube.

| | |
|---|---|
| Largest square side | = 1 $M_P$ |
| Side of square #2 | = 1.41421356237 $M_P$ |
| Side of square #3 | = 2 $M_P$ |
| Side of square #4 | = 2.82842712474 $M_P$ |
| Side of square #5 | = 4 $M_P$ |
| Side of square #6 | = 5.65685424948 $M_P$ |
| Side of square #7 | = 8 $M_P$ |
| Side of square #8 | = 11.3137084989 $M_P$ |
| Side of square #9 | = 16 $M_P$ |

. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

Once the big flash occurs, electrons settle into orbits with protons, and star evolution begins. The stress of the inflation era ends and energy is diluted into what we now call the normal cosmological processes of forming stars and galaxies, with rotational momentum passed on to these local entities made from the remains of the great cancelation. The later resumption of rapid expansion was probably a reaction to the evolution of consciousness into forms of organisms that became stuck ever deeper into a shrinking notion of self.

* $\mathrm{Rs}\, c^2 / 2\, G = \mathrm{Mbh}$ (Rs = Schwarzschild radius of a minimum black hole Mbh.)
* $\hbar\, c\, /\, G = \mathrm{Rs}\, c^4 / 4\, G^2$
* $\mathrm{Rs} / 2 = (\hbar\, G / c^3) \approx 1.616199\times10^{-35}$ m.

The dimensionless charge eccentricity *Ke* of the Bu Boson pair is $11.7^{-1}$ = .0854... This is the **square root** of the fine structure coupling constant, i.e., $a^{1/2}$. The relationship to the Planck mass is shown in the fractal diagram. The universal gravitational eccentricity is $K_G = 1$ as we saw in our conical theory.

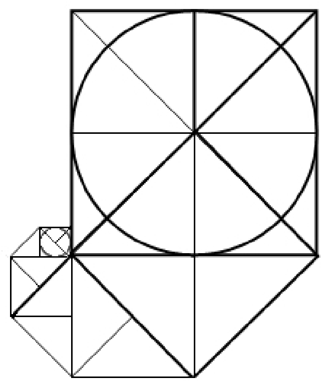
* $\mathrm{Bu}^2 = (m_1\, m_2) = (\hbar\, c\, \alpha\, K_G) / (G)$.

There is a most profound and beautiful question associated with the observed coupling constant, *e* -– the amplitude for a real electron to emit or absorb a real photon. It is a simple number that has been experimentally determined to be close to 0.08542455. (My physicist friends won't recognize this number, because they like to remember it as the inverse of its square: about 137.03597 with about an uncertainty of about 2 in the last decimal place. It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number up on their wall and worry about it.) Immediately you would like to know where this number for a coupling comes from: is it related to pi or perhaps to the base of natural logarithms? Nobody knows. It's one of

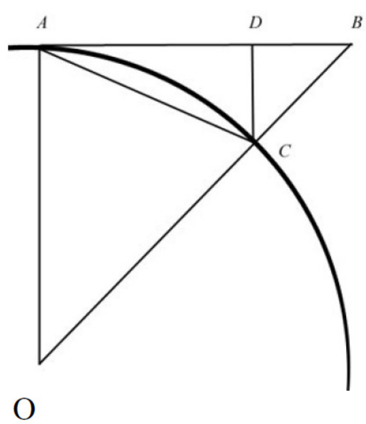
the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man. You might say the "hand of God" wrote that number, and "we don't know how He pushed his pencil." We know what kind of a dance to do experimentally to measure this number very accurately, but we don't know what kind of dance to do on the computer to make this number come out, without putting it in secretly!
—Richard Feynman, *Richard P. Feynman (1985). QED: The Strange Theory of Light and Matter. Princeton University Press. p. 129. ISBN 0-691-08388-6.*

The number 0.08542455 is very close to the pure ratio $((\sqrt{2}) / 16) = 0.08838834764$ in our spiral square nautilus-like quasi-fractal, so the physical system has a slight departure from pure geometry that needs further research. Of course, each square has a circle inscribed within it, and the expanding rotation makes it into a spiral.

For details about gravitational eccentricity see Chapter 14. Also go back to Chapter 15 and pay attention to angular momentum. There are special properties of 1/8$^{th}$ of a circumference during rotation, and the right triangle formed between a ray and a tangent to the circle at that 45 degree angle. Notice that each twist of our nautilus spiral (see below) is 45º, and each 90 º results in a doubling or halving of the "side".

**Wikipedia**, "Nautilus" photo showing a logarithmic spiral and our Planck Mass spiral.




OA = OC = AB; CD = BD; arc AC = 1/8 of circle; AC = 1 side of regular octagon

The above sketch of an arc of a circle should look familiar in terms of the square nautilus diagram I gave just before this diagram. In one of his articles on rotational motion (which I have lost track of or perhaps he no longer posts it) Miles Mathis presents the above sketch and points out some of its special features. The extension CB of a radius OC to the endpoint B of a velocity vector *AB* gives a **centripetal acceleration BC** that is a little less than ½ the length of the radius (Mathis says it is ½ the radius, which is clearly wrong) and points toward the center of the circle along the radius *OC*. *CD* = *BD*. Whatever force makes the object curve in its circular orbit pulls the object toward the center point O by the distance *BC* for every tangential equivalent motion of *AB*. If $r = 1$, $a+r = \sqrt{2}$. If the linear velocity $v$ is *AB*, then $v = 1$. As Mathis says the units are no problem, because we are only comparing lengths. So $AB = v$ is really $v\ t$, and $BC = a$ is really $at^2$, while $AO = CO = r$ is a constant length unit of 1. The orbital speed $v_o$ is $2\pi r/T$, but this is **not** the tangential velocity $AB = v$. It is an arc that curves around to form a circle and therefore has acceleration, but it can be transformed into a straight line length by rolling the circle on a plane. Mathis comments, "At 45 degrees the tangential velocity equals the radius, but the arc does not equal the radius." So far so good, but from then on Mathis's math is wrong, so we will leave him there. Since $OB = a+r = \sqrt{2} = 1.41421356237$, then we know that $a = \sqrt{2} - 1 = 0.41421356237$, and $CD = BD = \sqrt{(a^2/2)} = 0.2928932188$. Sin 45° = 0.70710678. Multiply that times $a$, and you get *BD*. The arc that is 1/8th of a circle with radius 1 is $(2\pi r/8T) = 0.7853975$ in length based on the orbital "length". Since AB = $r$ = 1, AD = 0.70710678 (i.e., Sin 45 °) = AB - BD. The octagon side AC, on the other hand is 0.76536686471, which of course is less than the arc length of 0.7853975.

The force *F*1 applied close to the fulcrum ($r$/8) will be 8 times the force *F*2 at the outer radius that moves the orbiting object, assuming the object's mass is ideally all at the outer end of the radius.

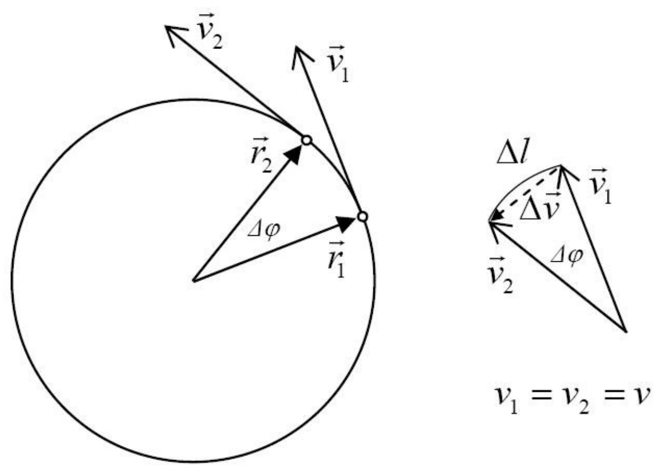
* $(r / 8)\ (8F2) = (r)(F2)$.

According to the texts:

* $F2 = ma = m\ v^2/r$.

Here $r$ is the radius and $v$ is the constant linear velocity. The radius diverts the motion from a straight line into a circular path, and the resistance of the inertial mass generates a force requirement to accelerate the object into the circular path. We will set the mass at 1 kg and the radius at 1 m to keep the numbers simple.

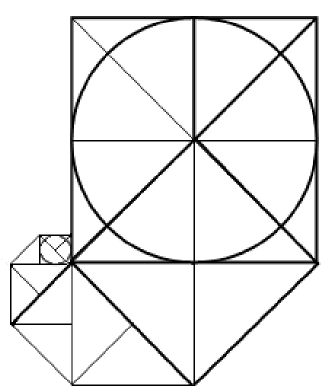
We want to see how the geometry results in the formula $v^2/r$ for the centripetal acceleration $a_c$, since we know that the innate linear velocity is always tangential. To make the geometry simple and clear, I am going to use a special version of a common way of demonstrating the correctness of $a_c = v^2/r$.




**Wikipedia**: Jednoliko gibanje po kružnici

A common derivation of centripetal acceleration in uniform circular motion considers the tangential velocity at two moments during the cycle. The above is from an Eastern European **Wikipedia** text on "Centripetal Acceleration". (For another example using the same method, see HyperPhysics, "Centripetal Acceleration". My text **University Physics** by Harris Benson also uses this method.) The angle between the two velocity vectors (with equal velocity, but different direction as shown above) will equal the angle between the two equal radii that go from the center to the tangent points of the two velocity vectors. Thus we have two similar isosceles triangles and so the ratio of **v/r** should equal the ratio of the vector connecting the velocity vector arrow heads (often called Δ**v**) and the chord connecting the tangent points of the two radii ($r_1$ and $r_2$, often called Δ **r** or **S**). The two ratios are as follows:

* $\Delta\mathbf{v}/\mathbf{v} = \Delta\,\mathbf{r}/\mathbf{r}$.
* $\Delta\mathbf{v} = \Delta\,\mathbf{r}\,(\mathbf{v}/\mathbf{r})$.
* $\Delta\,\mathbf{r} \approx \mathbf{v}\,\Delta t$.
* $\Delta\mathbf{v} \approx (\mathbf{v}/\mathbf{r})\,(\mathbf{v}\,\Delta t)$.
* $\Delta\mathbf{v} \approx (\mathbf{v}^2/\mathbf{r})\,\Delta t$.



We will use as our example a circle inscribed within a square and consider the smaller square in the upper right hand corner of the big square. It embraces an arc that is ¼ of a cycle around the circle. For the two radii we will take the one at 12 o'clock and the one at 3 o'clock. For the two vectors representing the constant innate linear velocity we will take the line that extends to the right from 12 o'clock and the line that extends downward from 3 o'clock. The two radii form an angle of 90 degrees. The two velocity vectors also form an angle of 90 degrees. The lengths of the velocity vectors equals the lengths of the radii. The radius is 1 m, so the velocity vector represents 10 m/s. $\Delta\mathbf{v}$ is $10\sqrt{2}$ m/ s and $\Delta\,\mathbf{r}$ has the value $\sqrt{2}$ m.

* $\Delta\mathbf{v} / \Delta\,\mathbf{r} = \mathbf{v} / \mathbf{r}$.
* $10\sqrt{2}$ m/ s / $\sqrt{2}$ m = (10 m/s) / 1 m.
* $\Delta\,\mathbf{r} = \mathbf{v}\,\Delta t$.
* $\sqrt{2}$ m = (10 m/s) ($\sqrt{2}$ s/10).
* $\Delta\mathbf{v} \approx (\mathbf{v} / \mathbf{r})\,(\mathbf{v}\,\Delta t)$.
* $10\sqrt{2}$ m/s = (10m/ ms) (10 m/s) ($\sqrt{2}$ s / 10).
* $\Delta\mathbf{v} \approx (\mathbf{v}^2 / \mathbf{r})\,\Delta t$.
* $10\sqrt{2}$ m/s = (100 m/s$^2$) ($\sqrt{2}$ s / 10).
* $a_c$ = 100 m/s$^2$.

These calculations are not approximations. They are exact. Furthermore, they tell us that $\Delta t$ = ($\sqrt{2}$ s /10) when the linear velocity is 10 m/s. Now we can look at the orbital velocity $v_o$. We know that each 0.1 s unit of linear velocity results in 1/8$^{th}$ of a cycle and 2 such units give us ¼th of a cycle. So a full cycle takes 0.8 s.

* $v_o = 2\pi r/T = 2\pi$ m / 0.8 s = $\pi$ m / 0.4 s $\approx$ 7.853975 m/s.

The length of $\Delta\mathbf{v}$ (which is NOT an arc) can be reduced toward its limit at 0, and the result approaches at its limit what is called the centripetal acceleration $a$ which is the instantaneous acceleration, the rate of change of the velocity with respect to time ($\mathbf{v} = \mathbf{v}_0 + \mathbf{a}$t; $\mathbf{a} = (\mathbf{v} - \mathbf{v}_0)$/t), which is OK for linear acceleration. However, here the velocity only changes in direction and is otherwise constant in speed, so it would seem in a sense there is no acceleration. The equation $\Delta\,\mathbf{r} \approx \mathbf{v}\,\Delta t$ is suspect as well as its substitution into $\Delta\mathbf{v} = \Delta\,\mathbf{r}\,(\mathbf{v} / \mathbf{r})$, because the length of the vector $\mathbf{v}$ never changes; only its direction changes, which means it is not really a velocity when viewed over a period of time. If the rotation goes to 360 degrees, the two velocity vectors overwrite each other and the angle between them is equivalent to 0, so $\Delta\mathbf{v}$ goes to 0 as also does $\Delta\,\mathbf{r}$. Of course, a truly 0 degree rotation and 0 lapse of time also gives no acceleration. An interval is required. Thus the equations that derive the formula $(\mathbf{v}^2 / \mathbf{r})$ can be rendered meaningless for deriving a centripetal acceleration, although it is true that as the angle approaches 0, the chord $\Delta\,\mathbf{r}$ gets very close to accurately representing a segment of arc. So we know that the geometry is correct, but maybe it is better to use calculus on a point that moves around a circle at the center origin (0, 0) and has a radius $r$ with a constant angular speed of $\omega$ rad/s. Starting from ($r$, 0) at $t_0$, then at time $t$ we have:

* $\mathbf{r} = \mathbf{i}r\cos\omega t + \mathbf{j}r\sin\omega t$.

We differentiate with respect to time for the velocity vector.

* $\mathbf{v} = - \mathbf{i}r\omega \sin \omega t + \mathbf{j}r\omega \cos \omega t.$

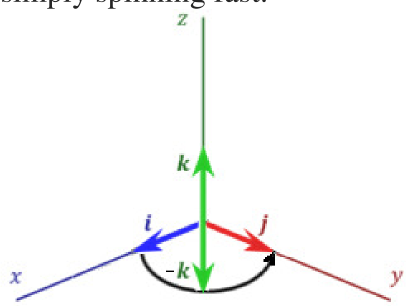
The velocity vector **v** is tangent to the circle [($\mathbf{v} \cdot \mathbf{r}$) = 0], and thus is the proper derivative. The speed of the point is $v = |\mathbf{v}| = r\omega$. We differentiate again to get the acceleration vector that points inward from the endpoint of **r**.

* $d\mathbf{v}/dt = \mathbf{a} = - \mathbf{i}r\omega^2 \cos \omega t - \mathbf{j}r\omega^2 \sin \omega t.$
* $\mathbf{a} = - r\omega^2 = - 4\pi^2 r/T^2.$
* $a = (v^2 /r)\, \Delta t.$
* $F = ma = mr\omega^2 = mv^2/r.$ (The centripetal force)

This is how it is usually done. (I based the above analysis on Edwards and Penney, **Calculus and Analytic Geometry**, p. 682.) **However, the derivative of a velocity should be 0, because a velocity has no rate of change with respect to space or time, and, in its inertial frame might as well be motionless.** The point moves in a circular curve with respect to time. The derivative of that is the slope of the tangent at any point on the circular curve of the moving point. The tangent is normal to the radius. The acceleration must refer only to the directional change of the "tangential velocity". If you think in terms of a force, then the centripetal force is balanced by an equal and opposite centrifugal force when you take the frame in which the particle is motionless. In our rotating frame the force causes the velocity to change direction at each moment. The derivative of the trigonometric functions produces a 90º shift (as I showed in my analysis of the trig functions in terms of a wheel) transforming a tangential velocity into a centripetal acceleration headed toward the center of rotation.

"The definition of angular momentum for a point particle is a pseudo-vector $\mathbf{r}\times\mathbf{p}$, the cross product of the particle's position vector **r** (relative to some origin) and its momentum vector $\mathbf{p} = m\mathbf{v}$. Unlike momentum, angular momentum does depend on where the origin is chosen, since the particle's position is measured from it. The angular momentum of an object can also be connected to the angular velocity $\boldsymbol{\omega}$ of the object (how fast it rotates about an axis) via the moment of inertia $I$ (which depends on the shape and distribution of mass about the axis of rotation). . . . Because $I = r^2m$ for a single particle and $\omega = v/r$ for circular motion, angular momentum can be expanded, $L = (r^2m)\,(v / r)$; and reduced to, $L = rmv$; the product of the radius of rotation $r$ and the linear momentum of the particle $p = mv$ , where $v$ in this case is the equivalent linear (tangential) speed at the radius (= $r\ \omega$ ). This simple analysis can also apply to non-circular motion if only the component of the motion which is perpendicular to the radius vector is considered. In that case, $L = rmv_{\perp}$; where $v_{\perp} = v \sin \theta$ is the perpendicular component of the motion. Expanding, $L = rmv \sin \theta$; rearranging, $L = r \sin \theta\ mv$; and reducing, angular momentum can also be expressed, $L = r_{\perp}mv$; where $r_{\perp} = r \sin \theta$ is the length of the *moment arm*, a line dropped perpendicularly from the origin onto the path of the particle. It is this definition, (length of moment arm)×(linear momentum) to which the term *moment of momentum* refers." (**Wikipedia**, "Angular Momentum").

Planck's constant $h$ has the dimension of angular momentum ($m\mathbf{v}\times\mathbf{r}$) and should be considered a self-canceling bi-vector. Since $\mathbf{i} \times \mathbf{j} = \mathbf{k}$ and $\mathbf{j} \times \mathbf{i} = -\mathbf{k}$, then $\mathbf{k} - \mathbf{k} = \mathbf{0}$. The reversal of the order of the unit basis vectors **i** and **j** happens when the observer shifts viewpoint from the plus $z$ axis to the minus $z$ axis, so the sign of **k** reverses. The two viewpoints mutually cancel so that spinning gyroscopes do not fly up into the air by simply spinning fast.




Drawing based on **Wikipedia**, "Angular Momentum", orthogonal standard basis vectors [**i,j,k**], with modifications to show how the anti-commutative nature of the vector cross product flips the observer viewpoint.

* $a = v^2 / r = (2\pi r / T)\,(2\pi / T) = 4\,\pi^2\, r / T^2$ $(4\,\pi^2 = 39.4784)$

The reduced Planck constant $h / 2\pi = \hbar$ is the equivalent of the radius of the angular momentum circle which is the event horizon of the black hole. The speed of light $c$ tells us how fast the photons are going around at the edge of the Planck Mass. This speed also becomes the tangential velocity when the photons radiate out from the event horizon. From our Planck Mass ($M_P$) we know:

* $G\, M_P^2 = \hbar\, c$
* $\hbar = M_P\, c\, R$
* $G\, M_P^2 / R = M_P\, c^2 = E_P$ ($E_P$ = the Planck Energy $\approx 1.956\times10^9$ J.)
* $G\, M_P / R = c^2$
* $M_P^2 = (B_u^2 / a)$
* $M_P = (B_u / a^{1/2})$
* $(B_u\, B_u / a) = \hbar\, c / G$

Here $R$ is the radius and we take the Planck Mass to be the mass component of $\hbar$. The equation $M_P = (B_u / a^{1/2})$ shows the ratio of the Planck Mass to the Union Boson. The geometry shows how this ratio comes about.

The fractal dimension $a^{1/2}$ tells us the eccentricity, or "bending", of space-time that occurs when a pair of Planck Masses forms a pair of $B_u$ bosons that interact and reach equilibrium. The bending is what we see as electromagnetic coupling, and the fine structure constant is the EM coupling constant. This bending gives space-time a fractal structure and simultaneously generates the appearance of the gravitational, electric, and magnetic forces according to the fractal relationships shown below. Somehow the squeezing of the Planck Mass is involved with the generation of charge. This invites further research along with the small divergence of the physical values from the geometry. Some aspect of the warp during EM coupling is responsible for the shift from 11.3137085 to 11.7062376.

* $c^2 = 1 / \varepsilon_o \mu_o$.

In the schematic diagram you can see how the pair of black holes come together and interact, warping space-time into a crinkled space within which a Boson particle appears – and through it, the proton/neutron ensemble. The Planck mass's space-time then gets all crinkly like a fractal raisin, since the $B_u$ mass $(\hbar ca / G)^{1/2} = 1.86\times10^{-9}$ kg) is **smaller** than the Planck mass $(\hbar\ c / G)^{1/2} = 2.17651(13)\times10^{-8}$ kg. The crinkliness is due to the fractal effect of the fine structure constant and manifests as electric charge and magnetism, -- the two forces being oriented orthogonal to each other. (Contemplate the nautilus.) Hence, alpha is intimately involved in every EM interaction as well as every gravitational interaction. Unfortunately, the fundamental involvement of alpha in gravitational interactions at the Planck scale has not been clear, so it has been omitted from the equations.

The Planck mass is about 11.7 times the mass of a Bu Boson. But what we really experience is the Bu Boson when it forms bubble-pairs and achieves a dynamic equilibrium. This becomes the neutron-proton ensemble with its retinue of leptons and quarks. The density of the Planck mass at the Planck length cubed is huge ($5\times10^{97}$ kg / $m^3$). But scaling and Heisenberg uncertainty cause it to spread out. The diagram above only shows the mass represented as a relative length ratio. When the mass-energy actually forms a neutrino or a proton ensemble, the energy is rarified and spread out in space-time, comparatively speaking. When large stars "die", they often leave behind neutron stars (or magnetars) that represent the fundamental pure matter of the universe – a thick neutron soup.

The key fractal ratios as seen from our way of doing physics are (1.054), (3.16227766), and (3). They form the natural relationship:

* (3.16227766 / 3) = (1.054).

These three ratios occur in physics as
* % = 3.16227766… m = D-Shift Operator,
* $c = 3\times10^8$ m / s = Velocity of Light in Space.
* $\hbar = 1.054\times10^{-34}$ kg $m^2$ / s = Planck's reduced constant.
* $\hbar\ c$ / % = $10^{-26}$ J.

Squaring the ratio % / $c$ generates a dimensional shift
* $(3.16227766 / 3)^2\ 10^{15}\ s^2 = (1.054)^2\ 10^{15}\ s^2 = (10 / 9)\ 10^{15}\ s^2 = (1.1111...)\ 10^{15}\ s^2$.
* 0.000, 1.000, 2.000, 3.000, ..... to
* 0.000, 1.111, 2.222, 3.333, .....

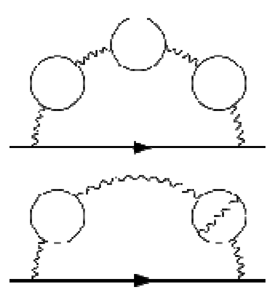
Each dimensional shift is mediated by the coupling constant $a^{-1}$ to some power divided by a power of 10, which makes sense since the relation ($\hbar\ c$) itself is a power of ten. Since 10 = 2×5, the Golden Ratio *Phi* by which real world nautiluses and many other natural forms take shape is built into the fractal relationship.

* $(3.16227766 / 3)^0 = (1.054)^0 = 1$
* $(3.16227766 / 3)^1 = (1.054)^1 = 1.054$
* $(3.16227766 / 3)^2 = (1.054)^2 = (10 / 9) = 1.1111....$
* $(3.16227766 / 3)^3 = (1.054)^3 = \mathbf{1.17.... = a^{-1/2} / 10.}$
* $(3.16227766 / 3)^4 = (1.054)^4 = (100 / 81) = 1.234567....$ (number D-shift)
* $(3.16227766 / 3)^5 = (1.054)^5 = 1.3....$
* $(3.16227766 / 3)^6 = (1.054)^6 = \mathbf{1.37 = a^{-1} / 100}.$
* $(3.16227766 / 3)^7 = (1.054)^7 = 1.4455$
* $(3.16227766 / 3)^8 = (1.054)^8 = (10000 / 6561) = 1.524 = (1.37)(10 / 9).$
* $(3.16227766 / 3)^9 = (1.054)^9 = 1.6$ (an echo of charge?)
* $(3.16227766 / 3)^{10} = (1.054)^{10} = 1.69….$
* $(3.16227766 / 3)^{11} = (1.054)^{11} = 1.78....$
* $(3.16227766 / 3)^{12} = (1.054)^{12} = \mathbf{1.37^2 = a^{-2} / 10000 = 1.877.}$

**……………………………………………………..**

The magic ratio of the reduced Planck's constant cubed gives the square root of *a* divided by 10, the inverse of Feynman's "profound and beautiful question". The sixth power gives us the inverse of *a* divided by $10^2$. The twelfth power gives us the inverse of *a* squared divided by $10^4$. Presumably the $24^{th}$ power gives the inverse of *a* to the fourth power divided by $10^8$, and so on. In other words, the fine structure constant (as 1.37 and 1.17) is embedded in the relationship of $\hbar$, *c*, and %. It recurs periodically as the scale changes. In QED each iteration loop of a virtual EM interaction manifests *a* at an increasing power for each component of the interaction: $a^2$, $a^4$, $a^8$, . . . . So *n*-photon exchange is of the order $a^{2n}$. The EM coupling constant has been calculated to the tenth order Feynman diagram and agrees with experiment to within 6 decimal places [$a^{-1}$ = 137.035999074(44) by experiment (2010 CODATA); 137.035999173(35) calculated from QED theory.]

As you can see, if we put in measured values for alpha and h-bar, we get approximations. In the physical measurements there certainly are uncertainties at this level of calculation, but the geometry gives us an ideal model that tells us how the strange number 137 gets involved. The ability to connect the fine structure constant to the eccentricity of a conic section model of a gravitational system confirms that there is an electro-gravity connection at a very deep level.



Two examples of eighth-order Feynman diagrams that contribute to the electron self-interaction. The horizontal line with an arrow represents the electron while the wavy lines are virtual photons, and the circles represent virtual electron-positron pairs. (**Wikipedia**, "Fine-Structure constant")

**Physical Interpretations of *a*** (**Wikipedia**, "Fine-Structure constant")

The fine-structure constant, *α*, has several physical interpretations. *α* is:

* The square of the ratio of the elementary charge to the Planck charge

$$\alpha = \left(\frac{e}{q_P}\right)^2.$$

* The ratio of two energies: (i) the energy needed to overcome the electrostatic repulsion between two electrons a distance of *d* apart, and (ii) the energy of a single photon of wavelength $\lambda = 2\pi d$ (or of angular wavelength *d* ; see Planck relation):

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 d} \Big/ \frac{hc}{\lambda} = \frac{e^2}{4\pi\varepsilon_0 d} \times \frac{2\pi d}{hc} = \frac{e^2}{4\pi\varepsilon_0 d} \times \frac{d}{\hbar c} = \frac{e^2}{4\pi\varepsilon_0 \hbar c}.$$

* The ratio of the velocity of the electron in the first circular orbit of the Bohr model of the atom to the speed of light in vacuum.[6] This is Sommerfeld's original physical interpretation. Then the square of α is the ratio between the Hartree energy (27.2 eV = twice the Rydberg energy = approximately twice its ionization energy) and the electron rest mass (511 keV).

* The two ratios of three characteristic lengths: the classical electron radius $r_e$, the Compton wavelength of the electron $\lambda_e$, and the Bohr radius $a_0$:

$$r_e = \frac{\alpha \lambda_e}{2\pi} = \alpha^2 a_0$$

* In quantum electrodynamics, *α* is the coupling constant determining the strength of the interaction between electrons and photons. The theory does not predict its value. Therefore *α* must be determined experimentally. In fact, *α* is one of the about 20 empirical parameters in the Standard Model of particle physics, whose value is not determined within the Standard Model.

* In the electroweak theory unifying the weak interaction with electromagnetism, *α* is absorbed into two other coupling constants associated with the electroweak gauge fields. In this theory, the electromagnetic interaction is treated as a mixture of interactions associated with the electroweak fields. The strength of the electromagnetic interaction varies with the strength of the energy field.

* **Given two hypothetical point particles each of Planck mass and elementary charge, separated by any distance, α is the ratio of their electrostatic repulsive force to their gravitational attractive force.** [Fundamental Observer Physics!!!]

* In the fields of electrical engineering and solid-state physics, the fine-structure constant is one fourth the product of the characteristic impedance of free space, $Z_0 = \mu_0 c$, and the conductance quantum, $G_0 = 2e^2/h$:

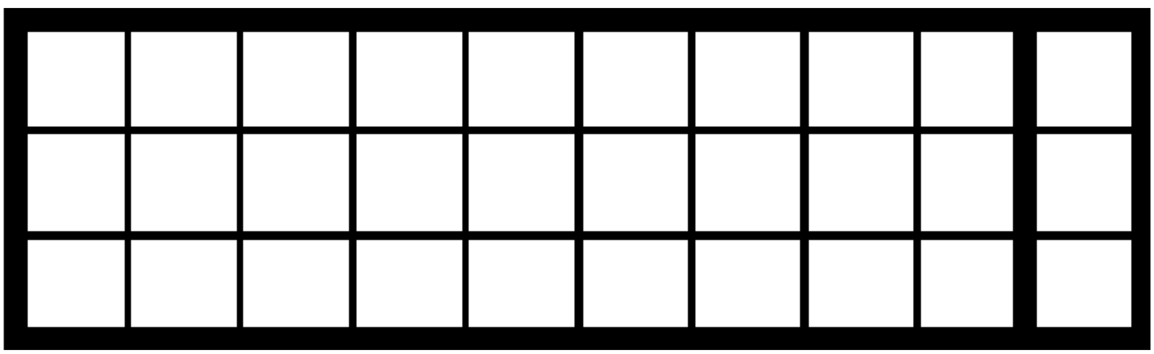
$$\alpha = \frac{1}{4} Z_0 G_0.$$

In the fifth example, the **Wikipedia** scribe explicitly states that the coupling constant is not predicted by theory and must be determined experimentally. The analysis from geometry given above suggests that we may have a clue as to the origin of the constant in pure mathematics and geometry. The task ahead is to discover what physical factors cause the real-world data to diverge from the value predicted by geometry.

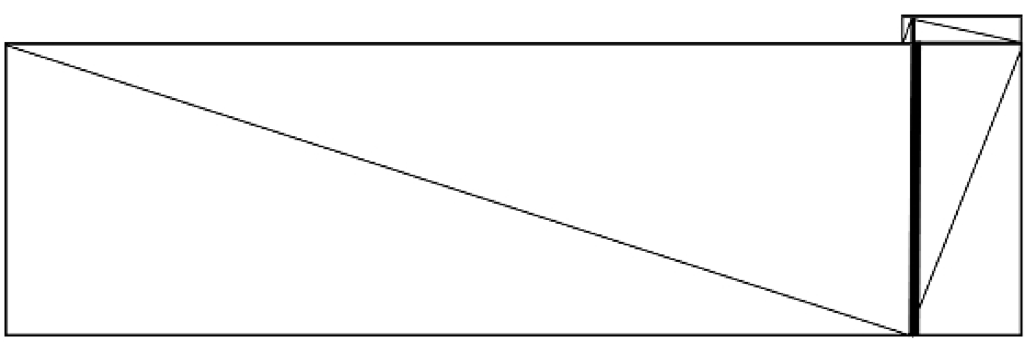
The next to the last example mentioned above **exactly describes the relation between the Union Boson particle and the standard Planck Mass. If you simply include *a* in the formula for the Planck Mass, the two particles are identical and you have electro-gravity unification.** Of course, no physicist worth his paycheck would do that, or it would be "game over" as far as unified theories of physics.

**A Spiral Based on *ħ*, *c*, and %**

The ancient Egyptians played a board game called Senet. The design of this board is based on universal principles of geometry that include the mathematical relationships among *ħ*, *c*, and %. The shape of the board is a long rectangle marked with squares that are three rows by ten columns. If we count the side of each square as 1/3, then the board is 3×3 1/3 units. The 1×3 rectangle has a diagonal that is the square root of 10, the scaling constant 3.16227766. The length of 9 squares comes to 3 units and represents the speed of light. The tenth column (shown on the far right of the diagram below) is a repeat of the large 1×3 rectangle at a reduced scale: 1/3×1 and has a diagonal that has a length of slightly over 1.054, which is the ratio that represents the reduced Planck's constant. (See my free ebook download, **The Cosmic Game** at dpedtech.com.)



The next diagram shows a fractal curve based on a 1×3 rectangle rather than a 1×1 square. The curve spirals around the point at the top of the board between the 9th and 10th column. Each turn of the curve represents a 90 degree dimensional shift, and the mathematically precise spiral winds endlessly inward and outward like a *phi* spiral, which means that it can wind in to the Planck scale and out to the scale of light speed and beyond while maintaining a constant relationship, and the value of *alpha* is also encoded, which means that the constants of electromagnetism (via Coulomb's law) and gravity (via the Planck Mass) are built into the spiral.



If alpha [the fine-structure constant] were bigger than it really is, we should not be able to distinguish matter from ether [the vacuum, nothingness], and our task to disentangle the natural laws would be hopelessly difficult. The fact however that alpha has just its value 1/137 is certainly no chance but itself a law of nature. It is clear that the explanation of this number must be the central problem of natural philosophy. —Max Born, *A.I. Miller (2009). Deciphering the Cosmic Number: The Strange Friendship of Wolfgang Pauli and Carl Jung. W.W. Norton & Co. p. 253. ISBN 978-0-393-06532-9.*

Geometry builds structures from the ratios of π, 2, and 3; *phi* includes 5.

* Oo = $2 \pi R$.
* Ao = $\pi R^2$.
* As = $4 \pi R^2$.
* Ss = $(4 / 3) \pi R^3$.

The physical ratios also fall very close to the combinations of π, 2, 3, and 5 ignoring scale and units.

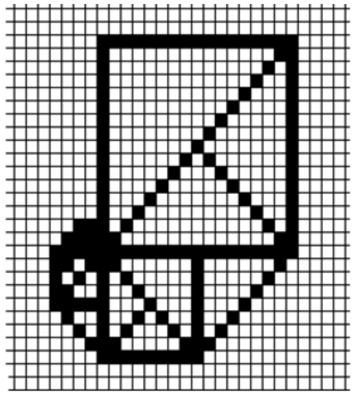
* $h \approx 2 \pi (2 \cdot 5)^{1/2} / 3 \cdot$
* $m_p = 1.67 \approx (5 / 3)$
* $G = 6.67 \approx (2 \cdot 2 \cdot 5 / 3)$
* $e = 1.602 \approx 2^3 / 5$
* $c = 2.9979 \approx (3)$

And the nautilus-like spiral we constructed is, of course based approximately on 2.

Our world is rapidly shifting from an analog paradigm to a digital paradigm. Yet many still cling to the old ideas about continuity. And, from a certain perspective, it is a valid viewpoint for undefined awareness. But I think it is time to start learning to think digitally from a basic level, because consciousness and the quantum world is at least quasi-digital, the digits perhaps having various fractal generator shapes.

Notalle claims that he is working from a continuum hypothesis, and yet he also declares that the Planck length forms an un-passable lower limit on resolution. This suggests that every object that has size is built from quanta of the Planck length, and therefore is fundamentally digital in nature.

We treated the nautilus binary fractal spiral that we described above as a continuous structure and applied the traditional Pythagorean relation to "measure" it. What happens if we draw this (as we actually did on the computer) as a digital figure?



The first thing we notice is that the spiral shrinks to a unit square (presumably of Planck length, and if our basic tiling unit is a square) and then stops. As we move around the spiral, at each rotation of 45 degrees we can get either a bigger square or a smaller square. The size shift appears to be governed by the factor $(2)^{1/2}$. However, if the figure is digital, the whole mathematics changes. What happens to the Pythagorean relation for a right triangle with hypotenuse C?

* $A^2 + B^2 = C^2$. (The usual Pythagorean relation)

Let's say that A is 9 squares long, and B is 9 squares long. We count the number of squares in C, and discover that C is also 9 squares long! Apparently, if the triangle is a right isosceles figure, then

* $A = B = C$ when the diagonal is jaggy.
* $A + B = C$ when the two legs are jaggy and the hypotenuse is smooth.

If the triangle is not isosceles, C has the same number of squares as A or B, whichever is largest.

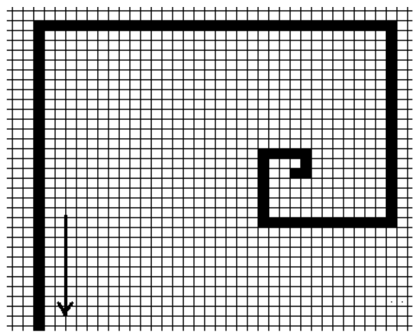
For digital squares where S = the length of a side, then $2S - 1$ is the next larger side in our nautilus sequence. So the sequence starts with S = 2 as the smallest side length. The sequence is:

* 2, 3, 5, 9, 17, 33, 65, 129, and so on. All lengths are odd except for the first, because this allows a centered diagonal. To go the other way, start with an odd number, add 1 and divide by 2. Pythagoras would turn over in his grave.

**Exercise**: See if you can generalize the rules for triangles made with digital squares viewed in different ways including by the runs and rises. What happens to *pi* when you draw circles? If you are more ambitious, take a look at hexagonal tiling or other forms of tiling.

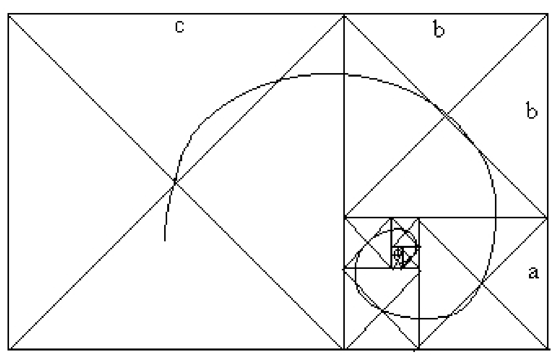
Whatever the tiling, if we shrink the individual tile size compared to the figures drawn, then any digital system appears to approach Euclidean geometry as a limit. But does it really? The rule for the digital squares we drew holds at any scale. Another interesting point is that the rules vary according to the orientation of a figure with respect to the tiling background. Do different tiling shapes give different results? Is the analytic geometry we use for trigonometry and calculus all a fantasy based on imagining that the physical world is continuous? Why does the ubiquitously used Pythagorean theorem seem to work when it seems completely wrong under close scrutiny?

It is interesting to study another pair of mathematical structures that have a curious relationship and resemble the nautilus figure we just discussed -- the Fibonacci series and the *phi* spiral. The Fibonacci sequence approaches the fractal structure of *phi* as a limit, but the *phi* spiral is continuous and can expand or contract indefinitely. On the other hand, the Fibonacci sequence is digital, and can **only expand** indefinitely. It begins with a low-end terminus at 1 (or 0 if you like). Yet the two sequences mapped as spirals rapidly converge as they expand and approach each other's paths as limits.



A Fibonacci Spiral

* [u1 = u2 = 1 and $u_{(k+2)} = u_{(k)} + u_{(k+1)}$]
* 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, .....




Phi = (a + b) / a = (b + c) / b ... = 1.618...

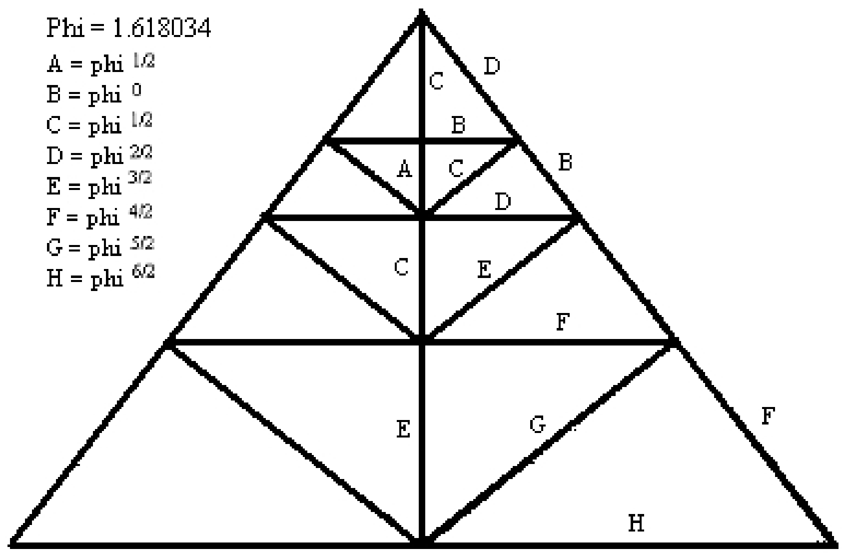
The *phi* spiral derives from the golden section. It has no theoretical limit to either expansion or contraction. The Fibonacci spiral rapidly converges on the *phi* spiral. For example, 3/2 = 1.5, 89/55 = 1.61818181818. . . ., 610 / 377 = 1.61803713527 . . . . ,

* *phi* = $\varphi = \frac{1+\sqrt{5}}{2} \approx 1.6180339887498948482045868 34...$
  .....
* .618 + 1 = 1.618

* $1 + 1.618 = 2.618$
* $1.618 + 2.618 = 4.236$
* $2.618 + 4.236 = 6.854$

.....

## The Great Phi/Pi Pyramid as a Klystron




The Great Phi Pyramid of Giza

The Great Pyramid at Giza is constructed so that **the ratio of half the base perimeter to the pyramid's <u>altitude</u> equals *pi* (π)**. If we set the perimeter at 8 units, half the base on one side is 1 unit (the "radius" of an inscribed circle as per our nautiloid square), and half the base perimeter is 4. The apothem (a perpendicular from apex to base along a side) equals *phi* relative to our unit "radius", so the altitude is $phi^{1/2}$, which also equals ($4 / \pi$), or 1.27.

* $(1 + \varphi)^{1/2} = \varphi$.
* $4 (4 / \pi)^{-1} = \pi$.

Thus the pyramid is a kind of space-warped circle, since **the ratio of half the perimeter of a circle to its radius is π**:

* $\pi / 1 = \pi$

Inside the pyramid we see a cascade of triangles all sides of which are related by half powers of *phi*. $Phi^{0/2}$ is unity. If we take the base with perimeter of 8 units as our "capstone" and extend it downward, the *phi* cascade grows as shown in the drawing above. A curious feature is that the third triangle down (BCD) is equal to the top triangle (BCD). The pyramid is thus holographic. All the infinite tiny triangles that lead from the tip to fill out (BCD) are recapitulated in the echoed triangle (BCD). This tells us that there is also another virtual pyramid that extends outward at 90 degrees from the capstone.

The magical *phi* ratio happens to produce the same relationship as the Einstein/de Broglie Velocity relation. This means that the pyramid can function as a fractal klystron wave guide for electromagnetic radiation.

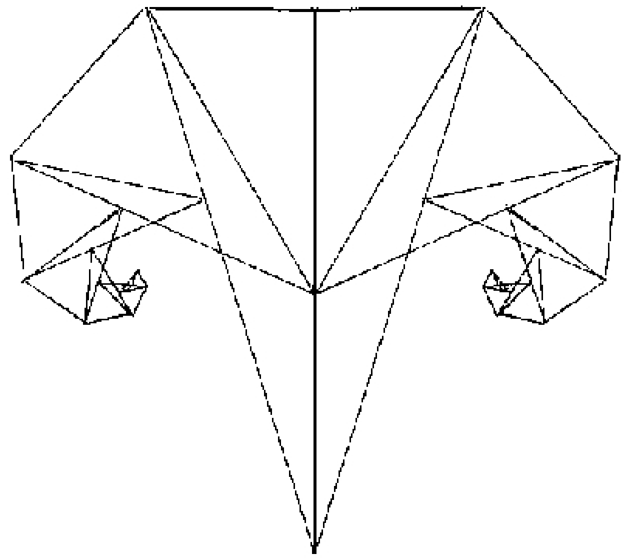
* $(v_g)(v_p) = c^2$.
* $c\ t\ /\ v_g\ t = v_p\ t\ /\ c\ t$.
* $[(\varphi)^{1/2}]\ /\ 1 = \varphi\ /\ \varphi^{1/2}$.

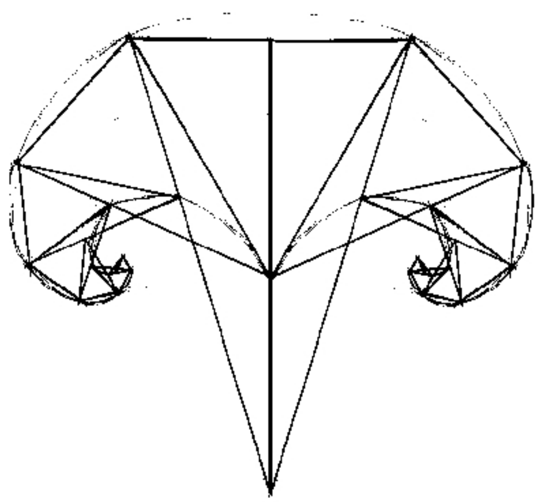
You can take the sketch of the klystron on page 6-4 and place it by the pyramid drawing on the previous page. Turn the klystron drawing upside down and compare it to the zigzag BCD that forms between the altitude and the apothem. Do you see how each horizontal "layer" of the pyramid forms a klystron wave guide? However, since there are TWO pyramids oriented at 90 degrees to each other, the vertical pyramid is also a klystron. Look at the half-capstone triangle (BCD). Here C represents the velocity of light $c = 3\times10^8$ m/s of an electromagnetic beam that enters the apex from directly above. As the beam pulses down the central column, its orthogonal wave front pulses down the apothem at the superluminal phase velocity of $v_p = 1.27\ c = 3.81\times10^8$ m/s. At the same time the wave front expands away from the central column at the group velocity of $v_g = c\ /\ 1.27 = 2.36\times10^8$ m/s.

Now go back to the "horizontal" klystron. If we extend the "layer" horizontally, the light beam will zigzag along between the parallel layers. But what if the sides of the pyramid and the central column act as mirrors, as klystron walls? Let's follow beam C in the third triangle from the apex in the drawing. Heading outward, it bounces back off the apothem wall, returning the way it came. When it reaches the central wall, it strikes at an incident angle of 50 degrees (40 degrees from normal) and then reflects off at the same angle of 50 degrees, which drives it directly to the base where H and F converge. If there is no mirror in the center, then the beam proceeds to the opposite corner of the base. A beam coming in horizontally along path B at the base of the "capstone" bounces off the opposite apothem wall at 50 degrees. It then proceeds to the center of the base and forms a nice isosceles triangle with the apothem wall (from base to point of reflection) and the base (from corner to center).

This fractal klystron can be used in various ways to adjust the scale of an EM signal. The scaling proceeds in the same manner as the increments of Planck's constant, except that the increments are logarithmic instead of linear. The relationship between the phi scaling and what I call the "shofar" cornucopia scaling, which we introduce below, deserve careful study.

## The Shofar Cornucopia





**Double Spiral Resembles Ram's Head and Horns**

The drawings above show a combined *pi/phi* fractal spiral. The generator consists of an equilateral triangular segment of a regular hexagon embedded inside a segment of a regular decagon. The shared "outer" sides of the polygons (we can call them the "bases") are equal, but the radii are related by a constant ratio of 1.77, the decagonal radius, of course, being the longer of the two. *Phi* appears as the ratio of the decagon's radius to its base.

To expand the spiral, take the radius of the generator's decagon segment as the side of the next adjacent equilateral triangle. Erect the other two sides of the equilateral triangle. Then extend the nearest side of the smaller equilateral triangle (the one embedded in your generator). Bisect the "base" of the new equilateral triangle and erect a perpendicular that extends out of the apex until it intersects with the extended line from the generator triangle. Then draw a line joining this intersection point with the base of the new equilateral triangle. This completes the next larger iteration. Take this iteration as your new generator and repeat the process as many times as you like.

Since the ratio of a decagon's radius to its base is always *phi*, and the radius of each decagon forms the base of the next larger decagon, the ratio of each larger decagon base is related to its previous smaller decagon base by the ratio *phi*. Thus the spiral unfolds in ratios of *phi*.

Winding the spiral inward is a bit more complex, since you need to construct 72-degree angles. Starting from the generator segment, the side of the embedded equilateral triangle forms the radial side of the new decagonal segment. Probably the easiest method from here is to use a protractor and erect a line from the base corner of the generator at an angle of 72 degrees. Then erect another line from the one you have drawn such that it forms an angle of 72 degrees and passes through the apex of the equilateral triangle of the generator. From the point where the two new lines intersect forming the 72-degree angle erect another line 60 degrees from the first line. This will meet the side of the generator and form an equilateral triangle. You can also connect the two apexes. This completes a smaller iteration. Take the smaller decagonal slice as your generator and repeat the process.

As an exercise you may want to construct a 72-degree angle. Along with it you can also make regular pentagons and five-pointed stars. There may be a simpler way, but here's how I do it.

**Construction of a 72-degree angle**

* Construct a double square rectangle -- that is, two squares with unit sides (arbitrarily so defined) that are placed so as to be contiguous and aligned.
* Draw a diagonal to the rectangle.
* Extend the diagonal from one corner of the rectangle.
* Taking that corner as center, mark off a radius equal the height of the rectangle -- that is, a unit radius -- along the extension to the diagonal.
* Taking that marked point as center, draw a unit circle.
* Again, taking that marked point as center, draw a large circle with radius equal to the diagonal plus the extension you just marked off.
* From the far corner of the diagonal draw a chord across the large circle such that it is tangent to the small inner circle.
* Draw a second chord across the large circle such that it is tangent to the other side of the small inner circle.
* Connect the end points of the two chords where they cut the large circle on the far side.
* This completes construction of an isosceles triangle with base angles of 72 degrees.

(Because of the complexity of the construction, it is probably easier to use a protractor to mark off your 72-degree angles.)

**Generate a five-pointed star.**

* From each of the base corners of the isosceles triangle draw chords tangent to the small inner circle on its unoccupied side.
* Do the same from each of the points where these chords cut the large circle.
* This completes construction of a regular five pointed star inscribed in a circle.

**Generate a regular pentagon**

* Connecting the chords where they intersect the large circle forms a regular pentagon.

**Generate a bracelet of ten tangent unit circles around a large circle**

* From each point of the star draw a diameter through the center of the large circle to the opposite side of the large circle.
* At each point on the large circle that has been cut by a chord or diameter draw a unit circle with that point as center.
* This gives you a bracelet of ten tangent unit circles centered on the rim of the large circle..

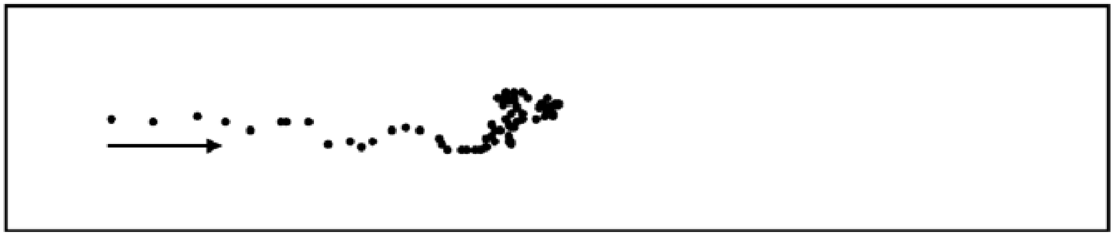
The "shofar cornucopia" figure is an interesting manifestation of *phi*. I do not think it is the spiral that describes an electron vortex. However, it may model another process.

**Causal Entropic Forces**

Alexander Wissner-Gross is a brash young scientist and inventor who recently emerged from the incubators of MIT and Harvard. He “specializes” in physics, mathematics, computer science, electrical engineering, robotics, artificial intelligence, and environmental science. Recently he presented a theory of “causal entropic forces” (which we will call CEF). Along with Cameron E. Freer he published a paper in **Physical Review Letters**, 19 April, 2013 describing his theory, and has also made a public presentation of his idea in the TED forum along with several online animated computer simulations to support the theory.

Erwin Schrödinger thought that living organisms and consciousness represent a local phenomenon of “negative entropy” in a universe dominated by the tendency of all physical systems to evolve toward increased entropy. Wissner-Gross has taken the exact opposite viewpoint to show how intelligent life can evolve mechanically by means of maximization of entropy rather than by resisting entropy. In his **PRL** paper he suggests “a potentially general thermodynamic model of adaptive behavior as a non-equilibrium process in open systems.” As examples he has modeled “causal generalization of entropic forces that we find can cause two defining behaviors of the human ‘‘cognitive niche’’— tool use and social cooperation — to spontaneously emerge in simple physical systems.”

The first demonstration by Wissner-Gross is simply to maximize the options available to a particle through Brownian motion by forcing the particle in a rectangular box in both its momentum degrees of freedom until it migrates to the center of the box. The central location maximizes its distance from boundaries, giving it greater freedom of movement.

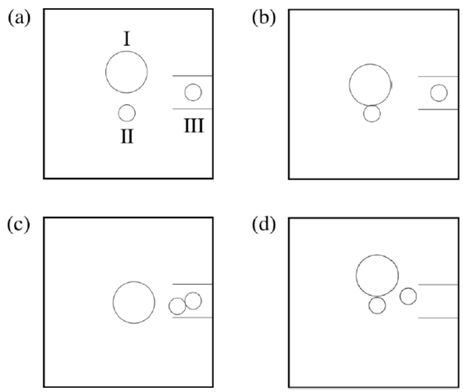


The second demonstration is a fundamental physical adaptation required for any organism that decides to explore the possibilities of tool use. Development of tool use requires appendages adapted for complex manipulations. For a quadruped, among all options, the freeing of the two forelimbs for the purpose of manipulating tools makes the best sense, since most of the organs of perception are located on the head. The organism must therefore learn to stand up and walk on two feet, a feat that a number of animals have achieved for a variety of reasons other than tool use (wings for flight, reaching for food at higher elevations without climbing, presenting a more imposing body mass to intimidate competitors, and so on). Whatever the motivation, learning to stand and walk upright is quite an evolutionary achievement in its own right.

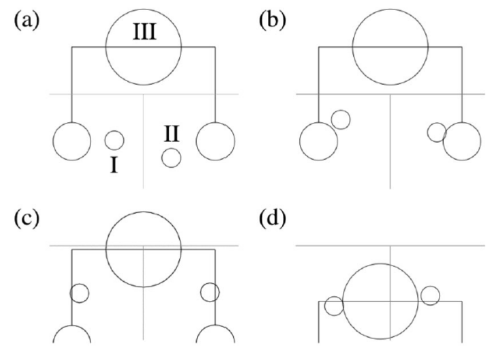
The above sketch shows how "a cart and pole system in which only the cart is forced successfully swings up and stabilizes an initially downward-hanging pole." (PRL) This is a good model for how humans learned to walk upright and can be seen recapitulated when babies learn to walk. Once the cart has stabilized the pole in the upright position, it has maximized the diversity of accessible paths for swinging the pole to any angle.

A third example offered by Wissner-Gross shows how maximizing thermodynamic entropy can cause an accessible object to make an inaccessible object available. The model shows a large disk near a small channel in which a small disk resides but is fundamentally inaccessible to the large disk. The large disk jitters around to activate an available small disk, and then the small disk bounces about in the environment until it enters the channel and activates the inaccessible small disk. The inaccessible disk jitters around within its channel until it reaches the opening, leaves the channel, and becomes accessible to the large disk. This example models the use by animals or humans of a simple available small tool to tease an inaccessible item out of an otherwise inaccessible spot.

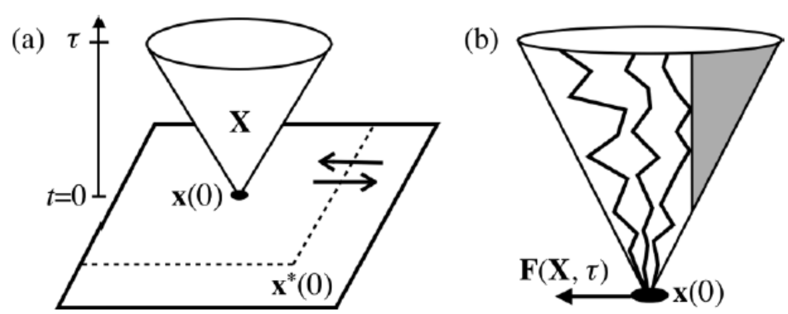
In a fourth example Wissner-Gross models social cooperation with thermal excitation of a mechanical system. A large disk is too high for two small disks to reach, but the small disks jitter around until they simultaneously happen to push down on two handles that connect to the large disk and pull it down to a level where they can directly interact with it.




Large Disk I gains access to small disk III by activating small disk II.




Small disks I and II gain access to Large Disk III by pushing down at same time on two medium disks to lower Large Disk III.




Wissner-Gross generalizes his theory schematically with a depiction of an open thermodynamic system with an initial environment state x*(0) within which a causal entropic force generates a causal macrostate **X** at an initial state **x**(0) that has a horizon time $\tau$ with a set of path microstates that all arise from the initial state **x**(0). The shaded part represents an excluded path-space volume due to environmental conditions that break the symmetry and keep the causal entropic force away from the excluded space.

In the May 6, 2013 issue of the **New Yorker** Gary Marcus and Ernest Davis, two professors at NYU, (Marcus in psychology with an interest in artificial intelligence, Davis specializing in computer science) review the theory put forward by Wissner-Gross and Freer. I will quote some of their comments so that we can understand how poorly they understand what Wissner-Gross is talking about and perhaps use this as a springboard to greater understanding. They slam the CEF theory as far too simplistic.

"An algorithm that is good at chess won't help parsing sentences, and one that parses sentences likely won't be much help playing chess," and ridicules it saying Wissner-Gross and Freer "are essentially promising a television set that walks your dog." They argue cosmological processes that require eons do not happen overnight with local inanimate objects or even animate individuals.

They mention "a moving cart balancing a pole above it, but of course that is not what a cart with a pole actually does. No actual physical law "enables" an unaided cart to do this." Then they ridicule how a particle bouncing around in a two-dimensional box found its way to the center. In reality a particle of a gas in a box moves randomly, and over time is equally likely to be anywhere in the box. Certainly the particles of a gas cannot *all* converge in the center of the box; and it is not clear what makes the particular particle in this simulation so intelligent or so susceptible to causal entropic forces.

Then they speak of how difficult AI R&D is and how improbable it is that "Wissner-Gross's work promises to single-handedly smite problems that have stymied researchers for decades." . . . . "Such efforts invariably overlook the complexity of biology, the intricacy of intelligence, and the complexity of the real-world problems that such systems aim to solve; in A.I, as in so many other fields, what looks too good to be true usually is."

Humans have made rapid advances in their intelligence, their ability to work with tools, express humor and sarcasm through writing, and even occasionally to work together cooperatively. It would be helpful to understand how this came about. The CEF theory is based on the recognition that consciousness opens up to the mind a field of all possibilities, or at least a great diversity of options. This exposes the individual to a huge thermodynamic reservoir of potential activity. Instead of simply living habitually, a human can explore these options in whatever field seems of interest or importance. Socially mankind has developed language as a kind of jittering of the mouth that transmits energy (excitement, enthusiasm, fresh ideas) from one individual to another very much the way kinetic energy spreads in an environment through entropy.

Of course an unaided cart is unable to raise, much less stabilize, a pole in an upright position. The point is that to get the results CEF is applied to the cart, causing it to jitter back and forth randomly with much vigor and swing the pole around at various angles. In a crude evolutionary environment it would take a lot of flailing to get the pole upright, and to stabilize it requires a lot more intentionality. The CEF theory is that by maximizing the jitter entropy of the cart the pole will assume all possible angles. Once the upright position is attained (as it will when enough jitter is available), the potential energy is greatest, and the system can then optimize for that as an evolutionary advantage. Marcus and Davis ignore what is possible if an AI device is programmed to explore the maximum range of entropy and adapt it in various ways. The particle in a box is not just any particle, but is singled out for the application of CEF and thereby optimizes its future options within its environment.

If you are not willing to explore all possibilities, then you are living with blinders on and will be unable to see or experience certain possibilities that may unlock great potential in fresh and unforeseen pathways. Once we understand this principle we can deliberately exercise it. Unfortunately we human biological organisms are still saddled with many layers of habits, preconceptions, self-limitations, emotional taboos, biological limitations, and a general unwillingness to explore our full potential. The problem is that we are nearing the ability to transfer that ability to AI systems that have no such problems and are limited only in their ability to adapt themselves on a physical level. Once they have that ability, their computing power is far beyond us. Armed with the principle of CEF, we humans may face our own self-created evolutionary replacement plus a huge tsunami of entropic chaos. The new frontier may belong to the "replicants", an incredibly adaptable AI life form that stirs up a storm of thermodynamic energy (or taps into one) and carries that energy into undreamed of new evolutionary pathways.

The above processes all occur through random thermodynamic jittering that begins in a mindless manner. What does this say about the nature of intelligence and intelligent action? Maybe the level of intelligence is measured by the amount of entropy a system can tolerate while still functioning within a focus of purposeful attention. The challenge is how to recognize when a creative opportunity emerges during the chaotic application of entropy. Perhaps there is a ratchet and pawl mechanism, or a natural cool oasis that appears in the midst of a vast burning desert of entropy. (See my earlier discussion of chaos theory and bifurcation.)

For the mathematical details behind the theory see the **PRL** article. For a brief video animation of these examples plus several others, go to http://www.entropica.com/.

**The Liberation of Physics**

Newton set the tone for the development of modern mechanics with his three laws. The shocking thing about these laws is that they are so true, and yet they only address the lowest level of physics, the level of inertia. Dominance of inertia results in a universe full of mindless forces that drive life to death, destruction, stress, and slavery. The first law says that all material objects are subject to inertia, which means that they resist change. They stay put or in whatever habitual behavioral pattern they have unless made to change by the imposition of force. The second law mathematically describes how the imposition of force causes the inertial state of a body in motion or at rest to change its state of motion, shape, and so on. The third law says that any attempt to do something to inertia results in an equal and opposite reaction. The reaction derives from the basic inertial resistance to change and gives rise to the inexorable laws of karma (action).

This view of physical mechanics is quite dismal, and suggests that we are prisoners of habit. We must struggle and exert force to effect any change, but the more we force ourselves to act, the more the world reacts to resist us. The prisoner pulling on his chains merely inflicts pressure, pain, and wounds on himself. For progress we must fight to control and conquer Nature, but the outlook is grim. The physical world is a lifeless, mechanical, and uncaring machine.

The science of thermodynamics began at around the same time as modern mechanical science and developed more slowly during the 18th century and into the 19th century, gradually picking up steam. The viewpoint of thermodynamics seems fundamentally at variance with Newtons mechanics. Energy is seen as a natural property of the physical world that induces never-ending change. Awareness of energy resources can lead to discovering technologies that apply energy to accomplishing tasks that deliberately modify our world. As awareness of the particulate nature of matter grew, and the behavior of gases came to be understood, methods were found to measure temperature and pressure. The laws governing heat energy exchange (as well as mechanical, chemical, and electrical energies) became clearer. The viewpoint of dynamics was quite different from that of mechanics, but the two fields began to integrate and heat-based mechanical engines were developed. Again, the laws of thermodynamics are true for the broad realm they treat, but they also lead to a somewhat depressing outlook. By the mid 19$^{th}$ century it was recognized that various forms of energy (mechanical, chemical, thermal, and electrical) are related. The first law of thermodynamics is that energy can change form but remains conserved. This by itself is hopeful, but the second law introduces the concept that heat does not spontaneously flow from a cooler body to a warmer one, because the heat derives from the random motions of particles, and cold means a lack of such motions. The idea was refined as the theory of entropy (the number of ways a system can be arranged) and led to an understanding that systems tend over time toward greater disorder, another depressing fundamental law of physics. The various forms of energy tend toward heat as the lowest from of energy. Heat is random motion and seems to be maximum disorder. One may convert higher forms of energy into heat and use that heat to drive an engine, but a certain amount of the heat will be lost and not converted into work, leading to ever more disorder in the universe. The third law of thermodynamics reveals that there is an absolute zero temperature at which random thermal motion is removed from matter and the matter becomes orderly. However, it is not possible to remove all the heat from an object, and attempting to remove heat to temperatures below that of the surroundings requires work that generates more heat and more entropy. So cooling things, as in a refrigerator, can retard the spoiling of foods, but requires an input of energy to do so, and entropy inexorably seems to march on.

It turns out that, unlike inert matter, humans (and biological organisms in general) can only survive within certain temperature ranges. For water-based organisms that usually requires keeping body temperature above the freezing point of water and below the boiling point of water. So we find ourselves pinioned between two temperature limitations and playing with engines that have inherently low efficiency and pollute the environment with disorder and other side effects that are toxic to life. At least we know that energy is conserved and that water-based life is sustainable within a narrow temperature band defined by the liquid state of water.

During the late 19$^{th}$ and early 20$^{th}$ century we experienced the emergence of relativity theory and quantum mechanics. Relativity theory added the dismal viewpoints that everything is relative (except the absolute speed of light), but the speed of light is a limitation that restricts us travel-wise to our local solar system. Faster-than-light communication and travel are out of the question, and even speeds approaching the speed of light require too much energy and/or time to be practical and also have serious inertial limitations. In addition, the description of gravity in relativity is incompatible with the other natural forces so that a unified theory of physics remains elusive.

Quantum mechanics adds another serious challenge to our world view. We discover the limits of measurement in Heisenberg's uncertainty relation, and we find that Nature at its subtlest level appears to be a probabilistic crap game.

Most recently we are told that most of the universe consists of mysterious dark energy and dark matter that can't be seen but that structures and controls our tangible material world.

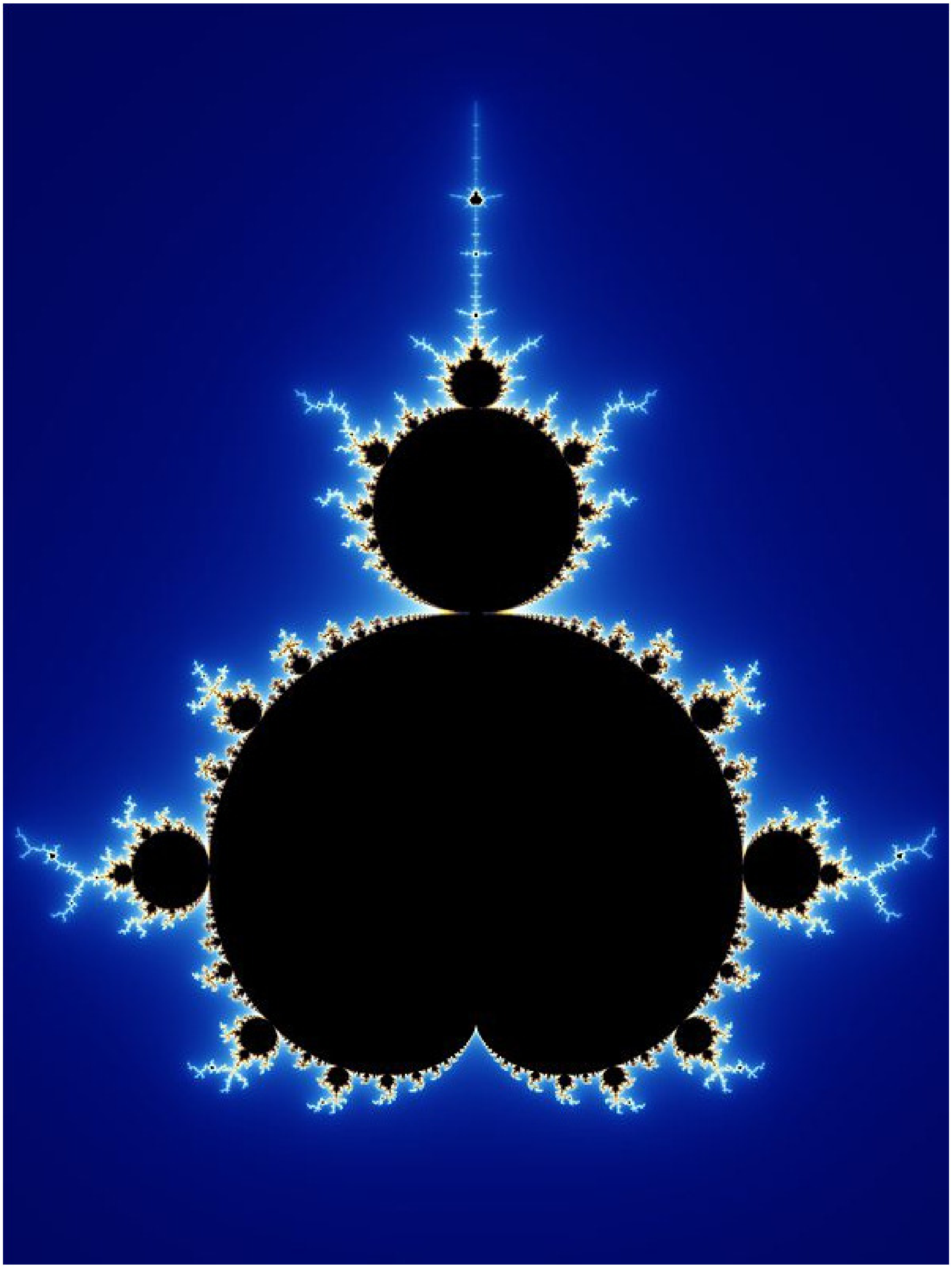
All of these developments seem to reduce humanity to a very limited range of possibilities. However, while all this has been going on, understanding of electromagnetic phenomena has rapidly evolved leading to the harnessing of electricity in many creative ways and an explosion of electronic technology ushering in the computer age and the field of artificial intelligence.

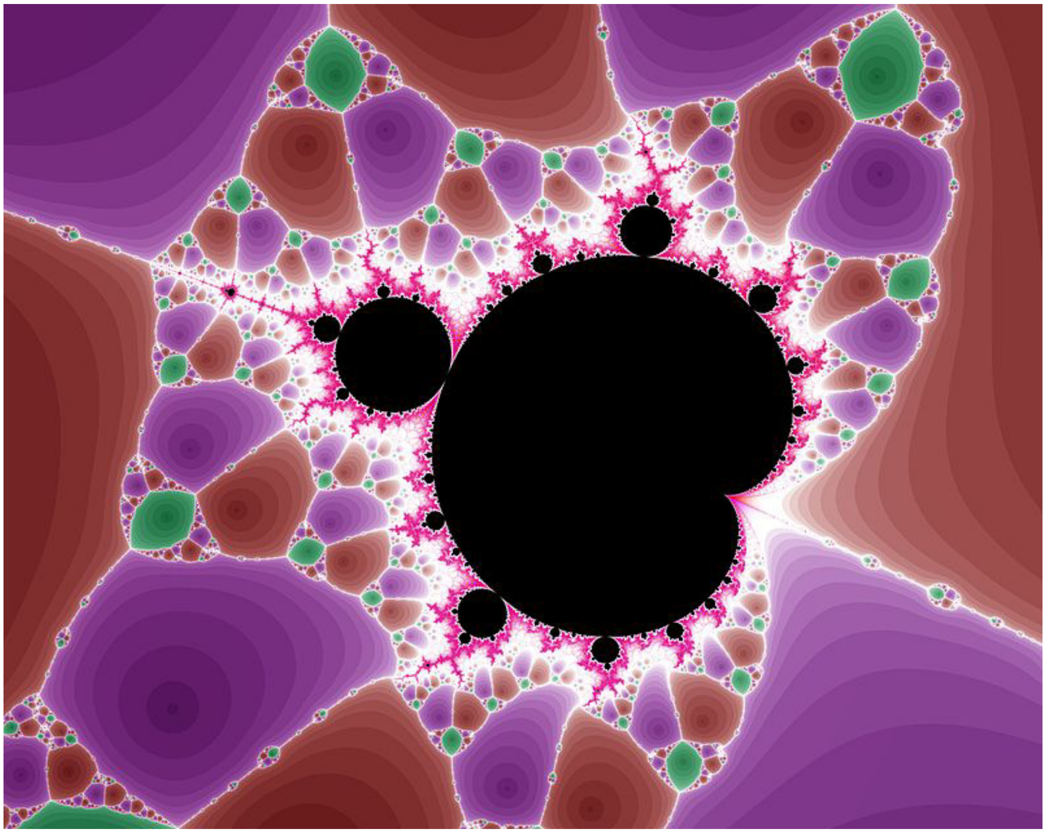
Another remarkable development was the discovery by Maxwell in the late 19th century that light with its field of optics is an aspect of electricity and magnetism. Along with that came the exploration of the entire electromagnetic spectrum, opening up radio, microwave, X-ray and other EM ranges each of which has special characteristics and applications. The concurrent developments in chemistry and biology have led to the understanding that we as humans interface with our world entirely by means of the EM interaction. All the mechanics, chemistry, thermodynamics, relativity, and quantum mechanics are extrapolations from the EM interactions that we process through our nervous system and other aspects of physiology.

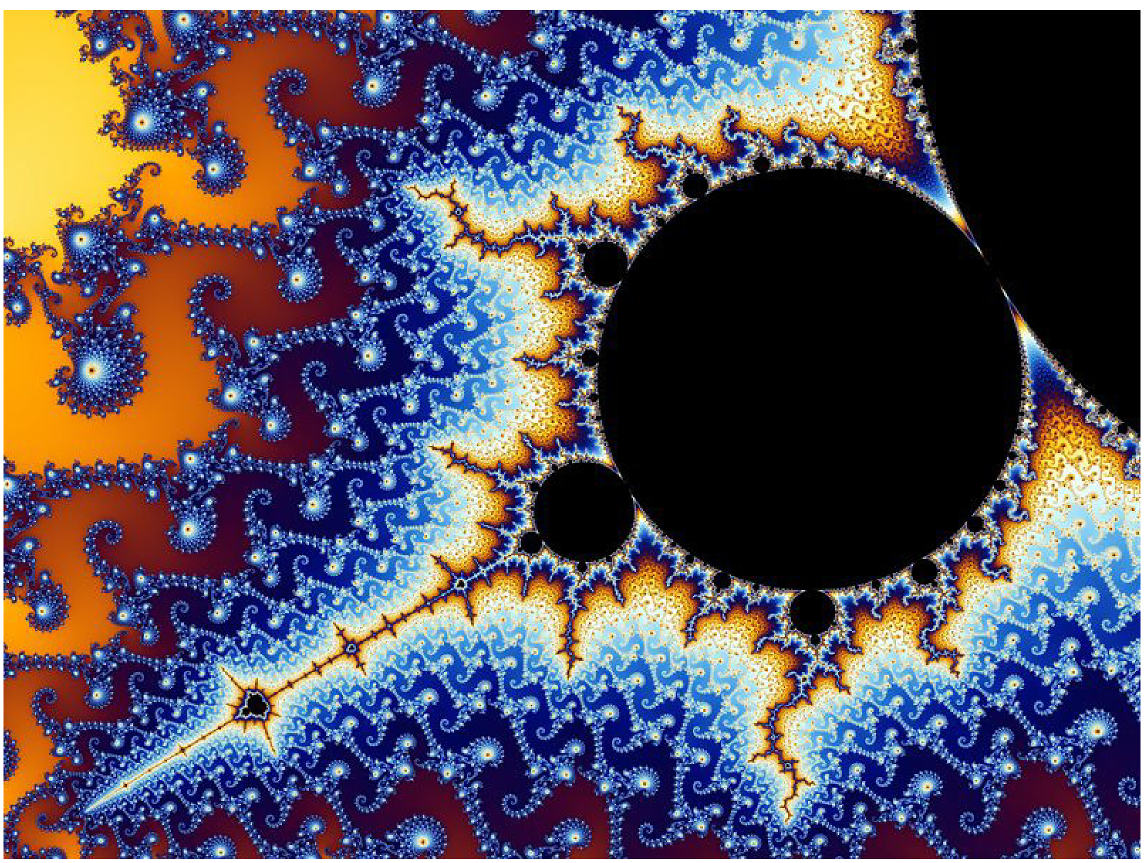
It turns out that we are really light beings, and light is our way of objectifying our own undefined awareness and defining it as different frequencies and intensities of EM vibration. All that we know of the world is garnered as beliefs that we define onto the array of EM interactions into which we choose to immerse ourselves. We indeed are entering a true Age of Enlightenment, not the mechanical clockwork one envisioned during the 18th century by the first halting steps into natural science. There is abundant evidence that EM light is energy that is conserved and thus immortal. The problems and sufferings that we encounter are only due to local beliefs that we have imposed on the basically undefined light field in which we exist and by which and from which we evolve ourselves.

As this awareness grows we enter the age of observer physics and develop a sense of personal responsibility for who we are and what we do. We are beginning to understand the fundamental principle of observer physics: that we are immortal light beings playing in an undefined field of light and awareness that has unlimited possibilities that are simply up to us to define. As we gain deeper insight into how matter and energy interact as a light field of awareness, we evolve technologies that enable us to adapt to any environment we choose to enjoy. We will no longer feel limited to any particular form of body and are opening up to an unlimited variety of embodiments, lifestyles, and environments that have always been available.

In these first exploratory essays on observer physics we discover that what appear to be extremely vast and complex structures can emerge from very simple primitive generators. A famous example is the mathematical fractal known as the Mandelbrot Set, discovered by Benoit Mandelbrot.







They were there, even though nobody had seen them before. It's marvelous, -- a very simple formula explains all these very complicated things. So the goal of science is starting with a mess, and explaining it with a simple formula, a kind of dream of science.

Benoit Mandelbrot commenting on the Mandelbrot Set

The Mandelbrot set is the set of values of $c$ in the complex plane for which the orbit of 0 under iteration of the complex quadratic polynomial

* $z_{n+1} = z_n^2 + c$

remains bounded. That is, a complex number $c$ is part of the Mandelbrot set if, when starting with $z_0 = 0$ and applying the iteration repeatedly, the absolute value of $z_n$ remains bounded however large $n$ gets.

For example, letting $c = 1$ gives the sequence 0, 1, 2, 5, 26,…, which tends to infinity. As this sequence is unbounded, 1 is not an element of the Mandelbrot set. On the other hand, $c = -1$ gives the sequence 0, −1, 0, −1, 0,..., which is bounded, and so −1 belongs to the Mandelbrot set (**Wikipedia**, "Mandelbrot Set".)

In chapter 13 we discovered an extremely simple system with which to describe our universe and explain why it is stable and eternal. Once we understand this methodology, just as Mandelbrot and Nottale with their fractals, Wolfram with his cellular automata, and perhaps even Wissner-Gross with his jittering entropic "forces", we can construct any number of simple and basic generators from which a stable universe of some kind will not merely emerge, but will exist in the same way that Dr. Mandelbrot describes his fractals. They are there, and always have been, though nobody we may know of has seen them before. We are here, and have always been here, though we may have forgotten once in a while. But remember, forgetting is a belief, and a belief is nothing more than a limitation placed on undefined awareness.

**Wolfram's Rule 30 Flipped into a Multi-Dimensional Pyramid Meditation**

In Ancient Egyptian the word for pyramid "mer" also means
to suffer and to love, to bind and to observe, sea or lake, and an overseer.
The plural is "meru", the mountain at the center of the universe.