Towards A New Paradigm?

Abstract: Arguments are presented for the contention that a new fractal cosmological paradigm is on the verge of replacing the previous standard paradigm of physics. The old and new paradigms are compared and contrasted.

I. Introduction

Several pieces of evidence suggest that we may be on the threshold of a revolutionary new paradigm for our general understanding of nature.

1. It has been over 400 years since the last comprehensive paradigm change from the Ptolemaic universe paradigm to the Democritus/Galileo/Newton paradigm of the modern era. General relativity and quantum mechanics offered profound changes in our thinking about nature, but they should probably be viewed as sophisticated refinements of the D/G/N paradigm, rather than a whole new paradigm. On the other hand, general relativity and quantum mechanics clearly point the way to the new paradigm, and in this manner they can also be seen as crucial precursor/transitional theories that will play a central roles in the new paradigm.

2. Problematic enigmas have cropped up in recent decades and this usually signifies that the limitations of an old paradigm are being reached and that there is a growing need for a new paradigm. Some of these problematic enigmas are:

    a. the incompatibility of general relativity and quantum mechanics,
    b. the vacuum energy density crisis,
    c. the very unnatural Planck mass,
    d. the enigmatic dark matter,
    e. the enigmatic "dark energy" acceleration,
    f. the heuristic nature of the standard model of particle physics,
    g. the negative results from the Large Hadron Collider
    h. the heuristic nature of quantum mechanics,
    i. the enigma of the fine structure constant,
    j. the enigma of Planck's constant,

k. the long-term failures of string theory, supersymmetry, quantum gravity models, "WIMPs" and Higgs boson searches, … , and
l. the inability of old paradigm models to generate definitive predictions.

3. New developments have pointed the way towards a new paradigm that can make progress on the problems listed above by offering a revolutionary new way of understanding and modeling nature. For example:

   a. In the last century galaxies were first discovered, then clusters of galaxies, then superclusters, and now there is theoretical evidence for structure far exceeding the extent of the entire observable universe. There is no longer any scientific reason to assume that nature's hierarchy has an upper limit.

   b. In the microcosmic domain, we have discovered atoms, and then subatomic particles. Any argument for a lower limit to nature's hierarchy at the Planck scale are pure speculation and devoid of empirical scientific evidence.

   c. For over 40 years there has not been a single observation of the highly touted WIMP dark matter particles. On the other hand, microlensing observations have turned up reproducible scientific evidence for hundreds of billions of stellar-mass and planetary mass dark matter objects.

   d. A discrete self-similar cosmological paradigm[1,2] has been developed over the last several decades. This new paradigm can explain past problems and enigmas, make definitive predictions, and offer a unique path toward a unified understanding of nature. It is called Discrete Scale Relativity when the discrete self-similarity is exact.[3,4]

The format for this article will be to present a table that succinctly summarizes in a succinct manner the contrasting assumptions and axioms of the old and new paradigms. This is followed by a more detailed discussion of principles, concepts and assumptions that define the competing paradigms and serve as their foundations.

Some caveats about the discussion are warranted. The contrast between the old and new paradigms is emphasized by choosing somewhat extreme forms of their modeling assumptions and principles. Therefore, although the differences between the competing paradigms are profound, in some areas they are not as mutually exclusive as it might initially appear. Also, there is a certain amount of redundancy in the presentation of the paradigmatic differences given here. It seems wiser to be a bit redundant concerning the relevant terminology and concepts than to risk omitting any terminology or concepts that might serve to highlight the differences between these competing worldviews on how nature works.

This essay is based around the contention that the new discrete self-similar cosmological paradigm has identified the fundamental principles and concepts that will form the foundation of the new paradigm for theoretical physics in the 21st century.

Table 1 Basic Distinctions Between the Old and New Paradigms

Old Paradigm	**New Paradigm**
Strict Reductionism	Restricted Reductionism
Platonism – Highly Abstract Foundations	Realism – Strong Empirical Foundations
Predominantly Linear	Predominantly Nonlinear
Differentiable Geometry	Quasi-Differentiable Geometry
Nature's Hierarchy: Restricted, Secondary and Local	Nature's Hierarchy: Unbounded, Primary and Global
Reversible Physics	Irreversible Physics
Exact Solutions	Approximate/Iterated Solutions
Acausality Allowed	Strictly Causal
Indeterminism Allowed	Strictly Deterministic

Integrable	Non-integrable
Conservative	Non-Conservative/Dissipative
Ergodic	Non-Ergodic
Exactly Repeatable Phenomena	Unique, Non-Repeatable Phenomena
Platonic Probability Arguments	Realistic Probability Arguments

II. A Discussion of Contrasting Paradigmatic Principles

Reductionism versus Multi-leveledness

One of the most important differences between the old paradigm and the new paradigm is the rejection of strict reductionism by the latter. Even though reductionism has been a very effective scientific tool for centuries, it has been pushed way too far since the 1920s. One need only study the development of a mammalian egg into a mature adult to realize that a description in terms of the actions of countless subatomic particles is completely impossible in practical terms and extremely dubious even in principle. Leading theoretical physicists of our era, e.g., Steven Weinberg, have argued that strict reductionism is the only rational scientific way to understand nature. I strongly disagree. There are *fundamental* objects at an infinite number of Scales discretely spaced throughout nature's infinite discrete self-similar hierarchy.

The Stellar Scale electron and proton are every bit as fundamental as their Atomic Scale analogues. Literally, the only difference is in their mass-space-time scale. Strict reductionism led to the incorrect assumption that the Newtonian gravitational constant was absolutely the same at all Scales of nature. This assumption caused theoretical physics to veer off course in about 1925 and drift ever-farther off course until the advent of Discrete Scale Relativity.

Simply put, if nature's Scales are exactly self-similar, i.e., equivalent except for discrete changes in mass-space-time scale, then strict reductionism is a fool's errand. *Within any single Scale*, e.g., the Atomic Scale or Stellar Scale, there is clearly an important role for limited reductionist modeling. However, when we are go beyond a single Scale, then we can no longer accept the strict reductionism that has dominated physics in the modern era.

Platonism versus Realism

The "string/brane theory" that has dominated theoretical physics in the modern era is an archetypal example of the Platonism that had increasingly infected theoretical physics since the 1940s. Platonism in physics can be characterized as an unhealthy, and nearly religious, belief in the absoluteness, inerrancy and supremacy of abstract mathematics when it comes to modeling nature. Realism, on the other hand, views mathematics as offering only artificial approximations of nature, and represents merely one of several tools that help in modeling nature.

Physical realism emphasizes empirical study of nature, and the prediction/testing of models, which is the *sine qua non* of the scientific method. Abstract theorizing is certainly not banished from science in the new paradigm, since it can offer highly useful results such as non-Euclidean geometry. However, abstract reasoning is never adopted as valid without adequate empirical testing. Otherwise we end up with something like "string/brane theory" that was claimed to be "the only game in town" and yet could not make a single definitive prediction after 43 years of hype.

For many decades the old paradigm also insisted on the Platonic notion of a perfectly homogeneous cosmos. The new paradigm emphasizes the global, unbounded and fundamental hierarchical organization observed throughout the cosmos, which is inconsistent with perfect Platonic homogeneity.

Linearity versus Nonlinearity

There was an initial emphasis in the modern era on seeking linear relationships in natural phenomena. This is understandable and led to good approximations for many phenomena. However, certain subjects such as gravitation, hydrodynamics and many astrophysical phenomena have always introduced strong doubts about how far linear theories could take us in understanding nature. With the advent of general relativity and nonlinear dynamical systems theory (deterministic chaos and fractal modeling) it became clear that nonlinear phenomena were the rule and linear modeling only applied in a limited number of approximations.

In the new paradigm we expect that the most detailed and accurate modeling will be nonlinear modeling, and that linear models will usually be heuristic approximations.

Differential versus Quasi-Differential Geometry

In the modern era, the theories that constituted the old paradigm were almost exclusively based upon smooth and continuous differential geometry. It was assumed that smooth and continuous differentiability was the only accurate concept for modeling nature. However, research into the quantum properties of the microcosm and certain oddities in the realm of pure math (e.g., the Cantor set, Peano curve, Koch curve, Julia sets, and other "monsters") began to question the fundamental assumptions of differentiability and integer dimensions.

The famous German mathematical physicist Hermann Weyl commented in his book *Philosophy of Mathematics and Natural Science* (1963):

> "One sees that both dimensionality and sense derive from the fact that affine geometry holds in the infinitely small. While topology has succeeded fairly well in mastering continuity, we do not yet understand the inner meaning of the restriction to differentiable manifolds. Perhaps one day physics will be able to discard it."

With the advent of Mandlbrot's fractal geometry, we have seen major progress in the effort to get beyond "the restriction to differentiable manifolds". Fractals are continuous, but they are decidedly not smooth and differentiable in the canonical manner. Fractal objects have structure on an infinite number of scales. They are as rough "in the infinitely small" as they are on macroscopic scales. Their self-similar structure does not disappear as one goes to smaller and smaller scales; instead it persists without bounds.

Do we have to give up differentiability, which is at the foundations of fundamental physics? No! But it is crucial to recognize that exact idealistic smoothness and differentiability are not accurate models of nature. Instead one must realize that differentiable manifolds are approximations. In fractal geometry, we can arbitrarily choose cutoffs to the extent of the hierarchy we are trying to model. Then we can use differential geometry as an approximation for this truncated coarse-grained model of reality. The key is that in the new paradigm the differentiability of the geometry and the modeling resolution of the relevant object must be restricted, and therefore involve approximations.

In general relativity, it was assumed that space-time is flat and exactly differentiable on infinitesimal scales. This will have to be changed. We can use this *approximation* as has been done successfully for nearly 100 years. However, we need to recognize that a more advanced and accurate version of general relativity will require that it incorporates discrete relativity of scale and the unbounded fractal geometry of nature.

Nature's Hierarchy: Primary versus Secondary

The old paradigm pays lip service to the fact that nature is organized hierarchically, but its emphasis on "origins" like the Big Bang, and its emphasis on strict reductionism, mean that it treats nature's hierarchical organization is a secondary, local and derivative phenomenon rather than being primary, global and fundamental. In fact, the old paradigm's reductionist tendencies cause it to virtually ignore nature's hierarchical structure in constructing theories.

The new paradigm offers a radically different and revolutionary vision of nature wherein its hierarchical structure, divided into discrete Scales like the …, Subquantum, Atomic, Stellar, Galactic, Metagalactic, … Scales, is intrinsic and without bounds. In the new paradigm nature's hierarchy is eternal, having no beginning or end. The "Big Bang" is reinterpreted as a commonplace supernova event taking place in our local Metagalactic Scale system. Likewise, there are no bounds on its spatial structure, such that there are no smallest nor largest objects in nature. Nature's hierarchy is timeless and extends forever in both the small and the large "directions".

Reversible versus Irreversible

The majority of the fundamental theoretical models that constitute the old paradigm involve reversible physics. This means that the equations run equally well backwards and forwards in time.

The new paradigm, on the other hand, takes the view expressed by nonlinear dynamical systems theory that all phenomena taking place in the real physical world are irreversible *if all relevant phenomena are included and no simplifications are used in the modeling*. Strict causality requires that systems evolve in time deterministically. Time reversible physics are viewed as rough approximations or Platonic fictions. This has a great deal to do with the fact that the new paradigm views any physical system as comprising an infinite hierarchy of subsystems. Such a system can only evolve forward in time and its evolution cannot be perfectly reversed.

Exact Solutions versus Approximate/Iterated Solutions

The temporal behaviors of complex nonlinear dynamical systems (NLDS) are not fully predictable. Their sensitive dependence on initial conditions, their nonlinearity and their infinite multi-leveledness deny the reality of "exact" solutions, and require more or less approximate solutions.

It is true that complex NLDS can exhibit periodic phenomena during their temporal evolutions and a degree of stability, but this in no way makes exact solutions possible, or conflicts with their intrinsic deterministic chaos when the time frame is long enough to include a full sampling of their behavior.

In the case of real physical systems, one must have a reasonably accurate model and then iterate the model to discover its temporal evolution or spatial structure. For example, no one could have had a very accurate picture of what the various Julia sets, or the Mandelbrot set, looked like until the generating equations were iterated a huge number of times on modern computers. An atom or a star can have periods of stability, relatively rapid changes of state, or periods of regular oscillations, but one cannot predict their exact behavior over long periods of time, especially since their environments are always "open" systems.

Causality versus Acausality

Simply put, the new paradigm asserts that everything that happens in nature does so in a completely causal and deterministic manner. The acausality introduced into physics by quantum physics is due to an incomplete, heuristic, and over-simplified modeling of microscopic systems that depends far too much on the limitations of the observer.

Therefore the new paradigm asserts that it will be necessary to reinterpret quantum mechanics in a *less observer-dependent* manner that yields a causal and deterministic version of the theory. Reinterpreting the Schroedinger equation's square of the wavefunction in terms of a physical mass/charge density distribution, instead of a probability distribution, is considered to be a required first step in this transition.

Determinism versus Indeterminism

Both quantum mechanics and nonlinear dynamical systems involve stringent limits on predictability, but the origins of these limits are different in the old and new paradigms.

The old paradigm invokes a fundamental indeterminism in the laws of nature.

The new paradigm asserts that the laws of nature are causal and deterministic, but our knowledge of any system and the relevant initial conditions are limited. It is these empirical limitations that gives rise to restrictions on our ability to predict the system's behavior.

Integrability versus Non-Integrabiliy

This distinction between old and new paradigms is intimately related to the differentiability issue which was discussed above. In an infinite fractal cosmos, one must accept approximate models if one wishes to work with integrable equations.

Closed Conservative versus Open Non-Conservative/Dissipative Systems

The old paradigm emphasized conservative systems and accomplished this by considering idealized isolated, i.e., closed, systems.

The new paradigm asserts that there are no closed systems in nature. Rather, everything in the infinite hierarchical cosmos is interconnected, albeit to differing degrees of directness and impact. While the new paradigm accepts the global conservation of mass/energy, charge and momentum that characterize the old paradigm, the new paradigm emphasizes *open, dissipative* systems that can be *far from equilibrium*. The use of conservative models is acceptable as long as it is clearly understood that they are approximations.

Ergodic versus Non-Ergodic Systems

The old paradigm emphasized ergodic systems with phase space trajectories in that could pass through any point in the phase space.

The new paradigm emphasizes non-ergodic systems whose trajectories in phase space are often quite limited - for example, to the points on a fractal strange attractor.

Repeatability versus Unique Time Evolution

In the old paradigm it was assumed that one could repeat events and sequences exactly.

In the new paradigm this can only be accomplished as an approximation – sometimes a good approximation and sometimes a poor approximation.

Platonic Probability Arguments versus Realistic Probability Arguments

During the last several decades theoretical physicists have tended to use excessively Platonic probability arguments to say the most extraordinary and improbable things. The new paradigm will correct these lapses of good physical judgement. Three examples will suffice to demonstrate the problems associated with the old paradigm and the solution offered by the new paradigm.

> <u>The Classic 10^{27} Particles Back-In-The-Bottle Argument</u>:
>
> Consider a giant "airtight" sphere one kilometer in diameter that contains a tiny vial holding 10^{27} molecules of gas, which is opened by remote control. The Platonists will swear up and down that it is mathematically guaranteed that there is a finite probability that the molecules will all spontaneously end up back in the vial. They are certain that if one were willing to wait long enough, then this miracle "must" *actually happen*.
>
> Except for Platonic fantasy worlds, this argument is patently false for any number of reasons. Given that no actual physical structure could really be "airtight", molecules would gradually leave the sphere and then the probability of ever getting these errant molecules back into the vial is effectively zero. After 1,000 years any sphere would surely be in far too decrepit condition for a realistic experiment. After waiting for several generations with only a relatively trivial number of molecules ever being detected inside the vial, the humans monitoring the experiment would undoubtedly decide that it was based on a ill-considered over-simplification and quit.
>
> <u>The Infinite Copies Gambit</u>:

Theoretical physicists have assured us that in an infinite Universe there would be exact copies of any human.

They forget that a human is the product of billions of years of evolution during which an uncountable number of unpredictable events could have caused major changes in that evolutionary sequence countless times. They forget that each human is the product of a unique and non-repeatable history from conception to its present age. They forget that even in the case of "identical" twins, a trained dog can distinguish which handkerchief belongs to which twin. If "identical" twins from the same planet are distinguishable, then it is infinitely improbable that that any two beings who have evolved on different planets are exact copies. It is a completely silly argument that is again based on unrealistically Platonic mathematical assumptions and a very poor understanding of biology and evolution.

<u>The Boltzmann Brain Delusion</u>:

During the last 10 years, respected professional theoretical physicists have claimed that thinking beings referred to as "Boltzmann Brains" can spontaneously "pop out of the vacuum". They have actually published papers on this delusion in respected physics journals, and there is a Wikipedia entry on "Boltzmann Brains" for those who like to marvel at what passes for serious physics in 2011. The lack of understanding of nature and biology is breath-taking.

These three examples all point to a major flaw in the old paradigm: it allowed unrealistically over-idealized probability arguments to be taken very seriously, when in fact they lead laughably erroneous results. In the old paradigm, Platonic mathematics was allowed to trump reason and observation, in spite of centuries-old lessons clearly teaching us that this attitude leads to pseudo-science.

The new paradigm puts a firm stop to this Platonic nonsense by insisting that all probability arguments be properly grounded in physical reality, and by insisting that to be taken seriously any probability argument must pass the same predictions/testing format required by physical science. We have suffered through enough neo-Platonism to last a millennium.

III. Conclusions

The worldviews of the old and new paradigms are radically different. The new paradigm is not merely a modification or extension of the old paradigm. The new self-similar cosmological paradigm represents a revolutionary break from the past.

Discrete Scale Relativity is the one theory that can predict the specific quantitative details of the dark matter mass spectrum. The old paradigm vaguely predicts that the dark matter is some form of WIMP, but cannot say anything very specific about the masses or physical characteristics of the hypothetical WIMPs. Because the dark matter constitutes the overwhelming majority of all matter in the Universe, the old and new paradigms can be unambiguously verified/falsified by their dark matter predictions, or the lack thereof.

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