Can we see reality from here?

T. H. Ray

1209 Norwood Rd
Lansing, MI 48917 USA
thomasray1209@comcast.net

Abstract

Ask an experimental physicist to describe reality, and she might speak in terms of discrete events—clicks, flashes, particle tracks. Ask the same of a theorist, and he might speak of the continuous phenomena of curves, symmetries, dynamic motion. Pressed hard enough, though, both will likely reach the same conclusion: reality isn't important to what a scientist does. Why not?

The choice between being and seeing.

Reality to a nonscientist is usually something of familiar substance—the chair in which one sits, the air one breathes, the images of events that actually happened, as opposed to what one imagines. Though sensuous experience isn't geometry, like the "chairs, tables and beer mugs" of Hilbert's ideal world, every sensuous form can in principle be abstracted into geometry.[1] And though tracks in an atomic bubble chamber look like nothing seen in the substantial world, impressions made on one's brain surface also don't resemble the real world that lies beneath that substance. Would one say that those impressions are not therefore real?

Scientist and non-scientist alike experience reality continuously and interpret events discretely. The question of discrete vs. analog is equivalent to asking— "What is real, the continuous experience or the discrete history?" To science, that's a distinction without a difference. Driven by data, science is only the demonstrated correspondence of theory to result. If philosophy intrudes, it is merely that science, as J. Bronowski elegantly asserted, is "… the search for unity in hidden likenesses."[2]

Both widely admired and ridiculed, a statement of the late logician-philosopher W. V. Quine, "To be is to be the value of a (bound) variable,"[3] either says everything or says nothing. A bound variable is chosen, integrated and vanished. That's kind of a digital clock, isn't it? One arbitrary tick from free to bound, like one rotation of the Earth, one half-oscillation of an atom, one instantaneous change of state, is in L.E.J. Brouwer's words, "a move of time."[4] Any mathematical act maps some point to another.

Discrete mapping leads us to ask what happens "before" the initial condition to which one attributes cause to a specified event; "what happened before the big bang?" is a leading question in cosmology. Quine would say that questions of nonbeing are not proper. However, the 14th century philosopher Jean Buridan proposed that an ass, placed equidistant between two piles of hay, would starve to death because there would be no reason for him to prefer one pile over another. In Quine's terms, Buridan's ass would be a free variable, forever seeing and never being, never integrated into the physical world.

A donkey is not a philosopher. Some movement however minute guarantees a choice. Our jittery world is apparently never at true rest—relative rest states suggest an arbitrary fixed point of reference, so that discrete choices from a continuous field are not necessarily random. One reasons that the way in which we experience a continuous order of discrete events has an evolutionary benefit:

“Time is what keeps everything from happening at once,” a quip usually attributed to John Wheeler, implies that events recorded and processed by one’s brain mechanics are discretely ordered and encoded. Were it otherwise, all choices *would* be random, and it would be hard to assign the property of cognizance to any organism. A world of Darwinian random mutation and natural selection is a continuous model of change from the perspective of an ideal map, i.e., a mathematical model. When one calculates outcomes from a field of infinite parameters, the great majority lead an organism to extinction. Yet conscious creatures play with loaded dice; “good” and “bad” choices, assuming that all strategies are rational, i.e., survival-based, depend on having at least one good choice independent of all environmental influences considered as a continuum. E.g., if a one-celled creature needs light to survive, it either has the motive ability to seek a light source in order to “be,” or it ceases to be when the light goes away.

At a higher level of complexity, e.g., in a predator-prey relationship, let’s assume (to keep it as simple as possible) that a rabbit has only three survival strategies: freeze; run in a zig-zag pattern; or run under cover. Against a wolf or a dog, freezing is probably optimal if the rabbit spots the predator first; otherwise, the probability of survival by running a zig-zag pattern is about 50% and ducking down a hole, 100%. Against a hawk or an owl, with the raptors’ advantages of an added dimension of mobility and superior vision, ducking for cover is likely the only sure option.

As with Buridan’s ass, when discrete survival options present themselves in a continuous field of variable values, some random factor determines the choice of the instant—yet what determines the random factor? If that sounds oxymoronic, consider Buridan’s ass as a corporation of cooperating cells (as indeed, all complex organisms are)—the individual variable-rate activities of every “department” of the corporation, down to the least unit, are bound to the others only by the requirements of task coordination, not by random movement. [See ref. 38] For any discrete choice, consciousness and cooperation are identical.

The art of active observation.

My friend, the Boston-based portrait sculptor Melisa Gerber, is working on a formalization of aesthetics, a theory she calls “good form.”

“I believe portraiture expresses the internal world of the sitter rather than that of the artist. In portrait sculpture, not only is this internal world revealed through form, but the form itself must be aesthetically strong. Good composition, an aspect of aesthetic form, reflects dynamics of the physical world. Art thus incorporates physics along with

psychology. As every person is unique and has their own internal world, a portrait sculpture would reflect both the universality of nature's laws and the individuality of the sitter. The interdependence of universality and individuality exists in biological forms and underlies beauty and complexity in art. Portrait sculpture provides a unique opportunity to explore the unification of an apparent dichotomy."
(http://www.melisagerber.com/bio.html)

Gerber's research is literally a "hands on" transaction, a participatory enterprise no less than the interaction of donkey and haystack, or a predator-prey relationship. It's a dynamic, flowing relation—with a shifting hub point. What we mean by that is that the interplay of discrete and continuous trade positions dynamically within the network of interactions. This phenomenon of dynamic centrality shows up empirically in communication networks.[5] And what are complex interactions, if not communication networks, in principle? What's striking about the Dan Braha—Yaneer Bar-Yam result in [5] is that time in the aggregate plays almost no role, i.e., just as in a nonrelativistic quantum system, $T \rightarrow 1$ and motion is barely time dependent, while—also as in a quantum system—the shorter the time interval in which events are observed, the more dramatically the state of the system may be seen to change.

The mathematician Leslie Lamport, who coined the term "Buridan's Principle,"[6] defines a distributed system as " . . . one in which the failure of a computer you didn't know existed can render your own computer unusable."[7] Just so. Isn't that in fact the meaning of quantum decoherence? In the same respect, Arthur Eddington was known to say of Heisenberg's uncertainty principle, "Something unknown is doing we don't know what."

Closely related is the problem of bounded rationality; decision-making is limited to available information, which is never complete. If it were, using our art analogy, given an infinite amount of time and information, Melisa Gerber would not simply create a perfect sculpture, she would in fact reproduce the subject itself in all its physical properties, an emulation that could not be distinguished from the original. There doesn't seem to be any physical principle that would inform us whether our world is "real" or "virtual."[8]

Just as general relativity tells us that "all physics is local," if Gerber's aesthetic sensibilities generalize to a falsifiable theory, all art is local as well. Indeed, in my own local world, graphic artist Carole Steinberg-Berk of Lansing, MI, impresses me with that same sense of "flow," of organic motion and dynamic exchange, and so does memoirist-poet Michael Steinberg of East Lansing, as even the title of such kinematic memories invested in his poem "Running Beaches"[9] would suggest. And it is perhaps too obvious that my wife Carole, a trained hypnotherapist, flows with her subjects dynamically, smoothly exchanging energy and information.

Whether admiring and experiencing art, or just getting through the day, we are confident that the reader can also cite personal—local— examples of the intersection of art, life and physics. Locality is more than an abstract physical notion; it is life as it is lived. Fame, as Braha and Bar-Yam have it, is a function of dynamic centrality in a time dependent network.

Ernest Dimnet wrote, “Artists possess eyes less made to love reality than to go straight to its essentials.”[10] Does not Dimnet’s observation apply as much to the physicist as to the artist? Isn’t that our object, the *essentials* of reality? And why only artists—is not life itself a symphony, a sculpture, a painting, a poem, a ballet? Every discrete event, independent of scale, is an exchange of energy, a mutual transaction, a transformation. Why stop at human works of art? Organisms, from we complicated corporations of cooperating cells to the simplest unicell creatures, vary in degrees of consciousness, yet there is no way in principle to determine zero consciousness, any more than absolute zero temperature is attainable in principle. Murray Gell-Mann said or implied that consciousness appears to be continuous throughout nature.[11] In spite of the popular belief that physics describes only the behavior of “dead matter,” conscious motion is not differentiable, in principle, from random. One experiences a continuous (analog) existence, sculpted, written, painted, spoken, performed, from the organization of discrete (digital) elements, a dance of discrete order with continuous feedback, whether positive or negative. Is our experience discretely ordered only in terms of brain mechanics, or is external nature so ordered? We don’t know. Science just isn’t about reality.

Of boundaries and becoming.

Yet if reality is irrelevant to science, why bother with digital vs. analog at all? Because:

The boundary between continuous experience and discrete event is the only demonstrably objective boundary, and it’s where all the interesting stuff is. The hidden likenesses in an infinitely self-similar, scale invariant world are hidden only in scale, like the repeating patterns of the Mandelbrot set.[12] If that’s what our world “really” is, the world is maximally complex. And that makes it a world of maximum variety, too, on which we will have more to say.

Compare Quine’s statement to one of Einstein’s: “Either everything is a miracle, or nothing is a miracle.”[13] When one does science, nothing is a miracle—scientific realism isn’t merely what one thinks is real. It’s what isn’t a miracle; it’s what remains when one stops believing in miracles.

Karl Popper speaks of metaphysical realism.[14] Stephen Hawking speaks of model-dependent realism.[15] Regardless of one’s philosophical bent, however, realism is form of objective value, with parameters on which we can agree, on which in some respect we *have* to agree. If Gerber’s aesthetic theory attains scientific status, it will only—and can only—be in the context of realism, because it will encompass that single standard in which we are compelled to agree that we have no choice.

The rub is, that that in which we have no choice is not dynamic and observer dependent, i.e., not local and so demonstrably not the world in which we actually live. An observer dependent reality will always admit at least one option—one path of escape, one fixed point.

If today's theories in mathematical physics seem overly complicated, it is largely because that which seems like a naively simple problem is often exceedingly hard. Consider a seminal problem in computer science, P vs. NP, which asks if there is a polynomial time solution (P) for every non-polynomial time (NP) problem—in other words, can we verify the solution to a hard problem (e.g., the traveling salesman problem) as easily as we concoct an algorithm for it? Seems pretty straightforward—after all, one can look at an assembled jigsaw puzzle and appreciate how the pieces are joined—until one contemplates the process of undoing it. Where to start? How to guarantee a unique solution, how to unbake the cake? Singer/songwriter Kris Kristofferson wrote, "There's a lot of wrong directions on that lonely way back home."[16] A puzzle that transcends a certain threshold of complexity presents an exponential number of ways to reverse a process than is practical to compute in a reasonable time.

We would like to think that the world is algorithmically compressible, that in the equation on a T-shirt, as Max Tegmark put it,[17] are the few simple symbols that bare all the world's secrets of its origin and its destiny. Undoing a continuously evolving piece of art, however, is a contradiction:

Trying to undo it, only adds more to it. Experiments change particle histories—is that choice or chance?

Choice adds energy to the system—but so does chance. Wrong directions happen whether we try and control the path or not. Nature chooses her brush strokes at random and produces novel forms, while we choose our strokes with purpose—like nature, exchanging and dissipating energy in the process—and produce novel forms.

What separates our process from the processes of objective nature? All told, it is information alone.

While our information processing capacity is finite, nature's is infinite, we know, because information is ordered only at the price of an increase in communication entropy,[18] and communication entropy, like energy entropy, ultimately does not decrease. Common wisdom notwithstanding, waste and redundancy are assets to creativity; nature's apparently infinite choices lead back to what Peter Atkins calls an "infinitely lazy creator."[19]

And sure—in an infinite field of discrete choices, the simplest choice, the least action, generates every possible future state at any discrete moment. There is only 0, 1, yes-no, being or not-being. Buridan's ass is not in a perpetual state of shuffling between one haystack and another; he will eventually come to thermodynamic equilibrium, i.e., die and cease to be, at least in the form in which he is accustomed to being cognizant of his local world. The discrete choice opens a new field of continuously branching probabilities—choices that branch to the limit of one bit of quantum information.

It's all about the structure of space.

There are important physical reasons that theorists overwhelmingly favor quantum field theory (the model that drives supersymmetric string theory)—most important, it allows a fully relativistic, background independent model (such as Edward Witten's topological quantum field theory[20]). If the field is infinitely extended (Einstein: "No space is empty of field"[21]), a dynamic theory of particle interaction can be incorporated into a classically continuous field of Hilbert space, without the restrictions imposed by three dimensions of space and one of time. The algebra of discrete events is therefore compelled to play a bigger role in physics, as Einstein himself deduced.[22] He just needed good physical reasons to incorporate extra discrete dimensions of space into a field continuum, and didn't find them. Today, we have.

String theory, that incorporates algebraic as well as geometric methods into a continuous quantum field model, has been criticized for having too many vacua, i.e., lowest energy state, solutions (some 10^{500}). On the one hand, those solutions guarantee classical and quantum gravity and all particle results in a mathematically complete model. On the other hand, they aren't the unique solution we'd like, and the unification energy limit is too high for direct practical experimentation, by any known method.

WMAP[23] and its predecessor probes have consistently told us that the cosmos is largely empty of ordinary matter, mostly flat, on the boundary between gravitationally open and closed, with a very slight asymmetry in background radiation that may account for Alan Guth's inflation hypothesis.[24]

How did it all start? Did the one "click," the digital singularity, actually happen, or does every world in the multiverse[25] including ours, remain in an eternal state of uncollapsed probabilities even though our measured probability of being is 1.0?

When we are being, all events to us are continuous; we have a history of connected experiences. When we are seeing, we see "things," external, discrete events. Does nature "see things?"—how would one know? We widely assume in classical physics that impersonal nature does not have a structure, such as found in our brain mechanics, that allows discrete differentiation of events into categories of things. What if evolving nature is mirrored in brain mechanics, however?—category theory[26] could then produce the most fundamental and nonperturbative model available, and the whole game of theoretical physics could change overnight. Most significantly, we could not even speak of things physical anymore, only categories of representation.

There is a growing interest in quantum information theory as fundamental physics. For if the world is made of nothing *but* information, no boundary exists between the mechanics of organic sensation and the statistical and quantum mechanics of inorganic matter. Indeed, David Bohm conceived the basis of thought (consciousness) in quantum theory[27] long ago, and the holistic quantum universe, with Basil Hiley, shortly before his death.[28]

It seems likely, though, that if information is physical reality, no component of an information system such we "information gathering and utilizing systems"—IGUS—in the words of Murray Gell-Mann, can see reality in a finite moment (William Blake's poetic license notwithstanding), because reality is always beyond the reach of finite existence.

An infinitely continuous reality, to be compatible with thinking, existence, consciousness—i.e., "seeing"—demands an orientable surface of the minimum two dimensions that string theory accommodates. The two dimension surface in fact makes the one dimension discrete order of events comprehensible, because a one dimension self interacting continuum is its own subject and object, of perpetual measure zero with no means of differentiation without specifying boundary conditions.

The Jacobson-Verlinde model[29 30] identifies gravity with quantum information in 3 + 1 spacetime, and so allows dynamic action. It is more or less obvious that the model begs information entropy, and therefore must be orientable: imagine a string of beads—as one pushes the beads ever more closely against one another, less energy becomes available (locally, closer to the first bead) to squeeze them tighter though nonlocal energy remains infinite. Entropy increases, as on the surface of a black hole, a phenomenon described by Bekenstein-Mayo [31] as a one-dimension information channel, a sink.

Nature always escapes infinity.

Model-dependent realism [10] informs us that if there is deep unity of nature, reality doesn't have to be entirely observer-dependent (local) so long as one can reconcile observations in a realistic, mathematically consistent and objective model. It shouldn't be surprising, therefore, that Hawking favors Witten's all encompassing M-theory as the capstone of theoretical physics, the unified theory that Einstein sought.

Hawking's grand design comes with an escape clause, though, which contemporary theorists have exploited. Gerard 't Hooft brings classical determinism to quantum mechanics[32]. The Jacobson-Verlinde model of entropic gravity may be a direct quantum scale analog to the open-system-type energy throughput necessary to the survival of biological systems,[33] a *perpetuum mobile* accessible only to a massless nonlocal reality and not to our low energy world of self organized matter, survival and death.

From nature's point of view, the price of reality seems to be life itself—and not just organic, biological, life. Every exchange of energy between any two particles in the universe—and in terms of computational mathematics, there are *only* two distinct particles in the universe, comprised of the information bit—restricts discrete classical computation to answers of yes, no, or a number in the probability interval between.

The nature of time has always been a big question mark in both mathematical and physical theories. If discrete, time has units of physically real duration described by natural numbers. If continuous, time is an illusion as described by general relativity, of reversible trajectory. If time exists in terms of the least action principle alone, Julian

Barbour is right—time is a nonphysical abstraction.[34] (Our own view is somewhere in the middle—see technical note).

Hawking decades ago dealt with the difference between analytic and discrete models by posing "no boundaries."[35] No boundaries in spacetime, no boundaries between continuous field and discrete event, because imaginary time is subsumed by complex space. And while controversy continues to dog all theories that depart from the immediate potential for empirical measure, Hawking's proposal among others hints at yet another reason that theorists favor quantum field theory.

According to Niels Bohr's correspondence principle[36], at some unknown point the boundary between discrete events and continuous classical physics smooths out. Einstein's "finite but unbounded" classical universe allows a surface on which a continuous field propagates, and so does the C* algebra in an *n*-dimension Hilbert space—where quantum theorists have gotten used to calculating observables, accounting for the nonlocal properties of quantum theory while maintaining classical parameters. It was perhaps only inevitable that Hawking—having already connected quantum phenomena with extreme effects of relativity at the black hole horizon[37]—would take his theoretical journey to the imaginary part of the complex plane where one can speak of imaginary time indistinguishable from space. Because C* is a one-point compactification of the two-dimension complex plane, its one simple pole at infinity allows one to speak of what happens when a trajectory extends "north of the North Pole" as Hawking puts it. In a word: nothing. There's no singularity, no place of infinite spacetime density where time ceases to exist. It's just a point in the complex plane, in which points are analyzed as lines. The "nothing" of imaginary time, however, is "something" when a particle trajectory crosses the *y* axis. Mathematically, this isn't difficult—the real line (*x* axis) has poles at minus infinity and plus infinity. C*, with its one simple "North pole" divides nothing from something; reality is what happens, so to speak, when things "go South"—a wave function in the Hilbert space traces a real particle path in real time, the state of "collapsed" form where we see it.

In this context, can one distinguish among three-dimensional forms except as positive, bounded by infinite dimensional (Hilbert) negative space and the positive direction of time and the space that surrounds and defines the forms embedded in it? Dual wave-particle reality guarantees the collapsed waveform of a Gerber sculpture whose duration is relatively long, as well as the whitecaps on a rolling sea whose duration is relatively short. The energy exchanges that happen continuously—and independently—remind one of Shiva's dance. Closer to the structure of science, however, one finds that this property of independence, of discrete form, is of key importance to the complex system model that compels varying rates of subsystem change so that "things" can be external to one another. Bar-Yam, e.g., showed that the problem of bounded rationality in network interactions is solved or mitigated by information technology integrated laterally, i.e., a distributed control system vice the conventional hierarchical communication path.[38] Bar-Yam's model is based on his theory of multiscale variety, in which "…for a system to be effective, it must be able to coordinate the right number of components to serve each task, while allowing the independence of other sets of components to perform their respective tasks without binding the actions of one such set to another." An obvious critical requirement for computability (assuming the universe is algorithmically compressible) is such a system of discrete schema that, like quantum mechanics, begs classical parameters, i.e., experience-based qualities, realism. And these qualities are all local; in Lamport's words, "A discrete decision based upon an input having a continuous range of values cannot be made within a bounded length of time."[39]

Computability & comprehension.

Paul Davies also addresses an information-based complex systems theory: "Might ours be the only universe that is both computable and cognizable? (Cognizability might demand both computability and depth, i.e., a certain level of organized complexity.) Alternatively, our universe might represent *maximum potential variety* in some sense." [40]

Maximum potential variety is satisfied in an observer dependent, scale invariant, universe in which independent subsystem changes vary in coordination strength at different scales of observation. Therefore, general relativity is preserved as a local theory of gravity; the nonlocal effects of quantum mechanics are preserved in the infinite-distance combined field influences of Mach's Principle (technical note).

The coexistence of local and nonlocal physics, which guarantees orientability and therefore time dependence, would seem to suggest duality between discrete (quantum) and analog (classical) theories, because the dynamics of Poincare′ recurrence[41] allows time symmetry locally while the irreversible mechanics of nonlocality preserves distinct probabilities for action within a temporally bounded locality of arbitrary $t \rightarrow T$. A century of theoretical physics, however, has failed to find smooth mathematical unification. If quantum information theories are correct, i.e., if the universe is made only of information, physical influences at any distance are not compelled to be smoothly connected, only correspondent, harmonic. This is equivalent to quantum entanglement in a complex Hilbert space. In a universe of scale invariance and infinite self-similarity, time-dependent interactions obviate the meaning of distance in favor of quantum least action. Then information, gravity—and time—are identical, and a mathematically complete nonperturbative theory of quantum gravity is within reach.

We conclude—without apology for the circularity of the argument—that we can see reality from here. Because *seeing* it is all that makes it real, cognizable in Davies' terms—even if *computing* it remains in an infinite superposition of states, and forever just out of reach.

for Holly

Acknowledgements:
Thanks to Melisa Gerber and David Gerber for kindly reading and commenting on a draft version of this essay and saving us from potentially embarrassing errors. Errors that may remain are our own.

References

[1] Hilbert, D. *Grundlagen der Geometrie,* Teubner, Leipzig. 1899
[2] Bronowski, J. *Science & Human Values*, Julian Messner, NY, 1956
[3] Quine, W. V. Pervasive. See *Quine, W. V. Stanford Encyclopedia of Philosophy* online. 9 April 2010; rev 30 April 2010
[4] Brouwer, L.E.J. *Brouwer's Cambridge Lectures on Intuitionism*, Cambridge University Press. 1981
[5] Braha, D. & Bar-Yam, Y. "From Centrality to Temporary Fame: Dynamic Centrality in Complex Networks." *Complexity* vol 12, no 2, pp 59-63. 2006
[6] Lamport, L. "Buridan's Principle," *research.microsoft.com/enus/um/people/**lamport**/pubs/**buridan**.pdf* 1984
[7] Lamport, L. Attributed by Answers.com: http://www.answers.com/topic/leslie-lamport, to ref 20, e-mail communication, 1987. Retrieved by Answers 16 April 2007; site accessed 5 February 2011.
[8] Whitworth, B. "Exploring the Virtual Reality Conjecture." FQXi essay contest. 2011
[9] Steinberg chapbook, East Lansing, MI c. 1995
[10] Dimnet, E. *The Art of Thinking*, Folcraft Library. 1929
[11] Gell-Mann, M. *The Quark and the Jaguar,* Macmillan. 1995
[12] Gleick, J. *Chaos: The making of a new science*. Penguin. 1988.
[13] Einstein, A. Variously attributed.
[14] Popper, K. *Realism and the Aim of Science*, Routledge. 1983
[15] Hawking, S. & Mlodinow, L. *The Grand Design*, Random House. 2010
[16] Kristofferson, K. "The Pilgrim" 1971
[17] Quoted by Kaku, M. in *The Physics of the Impossible*, Doubleday. 2008
[18] Shannon, C. "A mathematical theory of communication," *Bell System Technical Journal*, vol 27, pp 379-423 and 623-656, July & October 1948
[19] Atkins, P.W. *Creation Revisited*. W.H. Freeman. 1992
[20] Witten, E. "Topological quantum field theory," *Comm. Math. Phys. 117, no 3 pp 353-386*. 1988 (thanks to Springer-Verlag & Project Euclid for open access.)
[21] Einstein, A. *Relativity, the Special and the General Theory*, 1952. Routledge Classics, 2001
[22] Einstein, A. *The Meaning of Relativity*, Princeton. 1956
[23] http://wmap.gsfc.nasa.gov/ Wilson Microwave Anisotropy Probe. Page updated 29 October 2010
[24] Guth, A. *The Inflationary Universe: the Quest for a New Theory of Cosmic Origins*. Perseus. 1998
[25] Everett, H. "Relative state formulation of quantum mechanics," *Rev. Mod. Phys.29, 454-462*. 1957
[26] Baez, J. http://math.ucr.edu/home/baez/categories.html 12 April 2006
[27] Bohm, D. *Wholeness and the Implicate Order*. Routledge. 1983
[28] Bohm, D. & Hiley, B. *The Undivided Universe*. Routledge. 1993.
[29] Jacobson, T. home page http://terpconnect.umd.edu/~jacobson/ 20 September 2005
[30] Verlinde, E. home page http://staff.science.uva.nl/~erikv/ Papers/talks dated 2010
[31] Bekenstein, J. & Mayo , A. "Black holes are one dimensional." *Gen. Rel. & Grav. 33, 2095-2099*. 2001
[32] 't Hooft, G. "Quantum mechanics and determinism at the Planck scale," lecture http://www.phys.uu.nl/~thooft/quantloss/index.htm 11 September 2000
[33] Prigogine, I. , Glansdorff, P. *Thermodynamics Theory of Structure, Stability and Fluctuations*. Wiley-Interscience. 1971.
[34] Barbour, J. web site http://www.platonia.com/ updated 5 June 2010
[35] Hawking, S. *A Brief History of Time.* Bantam. 1988
[36] Bohr, N. *Niels Bohr, Collected Works, Volume 3, The Correspondence Principle* Rosenfeld, L.; Nielsen, J. Rud, eds., *(1918–1923)* pp 241-282. Amsterdam-North Holland. 1976
[37] Hawking, S. *The Grand Design*. Bantam. 2010
[38] Bar-Yam , Y. research article "Multiscale Variety in Complex Systems," *Complexity*, vol 9, no 4, pp 37-45, Wiley. 2003
[39] Lamport, L. "Buridan's Principle" *op. cit.*
[40] Davies, P. in *Complexity,Entropy and the Physics of Information*. P. 66. Westview Press. 1990
[41] Web source http://www-users.math.umd.edu/~lvrmr/History/Recurrence.html Updated24 August 2001

TECHNICAL NOTE:

Mach's Principle & the relativistic theory of the non-symmetric field.

What Einstein named "Mach's principle" frames the universe as a dynamic relation among mass points. Einstein found Mach's mechanics inadequate for a complete theory [22, pp. 107-108], because it divides time and space (as all previous classical theories did) into absolute and independent qualities. Mach's universe was finite and bounded in space. Because "From the standpoint of epistemology it is more satisfying to have the mechanical properties of space completely determined by matter …" Einstein's finite but unbounded, quasi-Euclidean model of relative matter rest states came mathematically complete, with the origin of inertia assumed at the boundary of a singularity, and otherwise unexplained.

Even though both Mach and Einstein believed, however, that space is essential for any particle interaction, we find that space is not required for Mach's mechanics—though time is. In other words, while Einstein's universe is finite in time and unbounded in space, there doesn't seem to be any physical principle that prevents a universe from being finite in space and unbounded in time.

I.e., the instantaneous relation between two bodies spans a zero time interval, while the dynamics of n bodies > 2 depends on a lapse of time $(t \neq 0)$ in which the coordination of the movement of bodies at different rates of communication determined by the speed of light constant is in turn governed by the inertial centers of mass of bodies within local communication.

At non-relativistic distances, the field influences of electromagnetism overwhelm gravitational effects, which become negligible. Because the gravity field is symmetric (time reversed) and the electromagnetic field—the solutions to Maxwell's equations that we consider "real," the retarded solutions—are not time-symmetric, a classically unified field is not tractable to a continuous field model. It is apparent that time independent of spacetime defines the difference between mechanics and communication. There is no infinite communication among bodies in general relativity—all physics is local and time is an illusion.

In an extradimensional universe of finite space and unbounded time, nonlocality is satisfied, and time asymmetry exists as a field influence declining over n dimensions, $n > 2$. In the classical domain of 3 + 1 dimensions, Einstein is correct that all physics is local—time reversed symmetry inheres in a universe of even dimensions because the fundamental 2-dimensional complex plane is time symmetric with respect to spatial coordinates; time and space coordinates are not differentiable. However:

Every even (complex) dimension model, $n \geq 2$, reduces to a $0+1$ spacetime. In his last published work [22, appendix II], "The relativistic theory of the non-symmetric field," Einstein gave three examples of 4-dimensional fields of increasing complexity:

i. The scalar wave equation $\phi_{,11} + \phi_{,22} + \phi_{,33} - \phi_{,44} = 0$

ii. Maxwell's equations for empty space $\phi^{ik}{}_{,8} = 0$; $\phi_{ik,l} + \phi_{kl,i} + \phi_{il,k} = 0$

iii. The gravitational equations for empty space $R_{ik} = 0$; $g_{ik,l} - g_{ik}\Gamma^{8}_{il} - g_{i8}\Gamma^{8}_{lk} = 0$

Einstein noted that Riemann extended his theory of 2-dimensional surfaces to spaces of an arbitrary number of dimensions of Riemannian metric properties, resulting in the general expression for curvature in higher dimensional metric spaces.

Leaving aside the arguments and mathematics with which Einstein justified his (failed) "… logically simplest relativistic field theory …" we address his assumed limitations to a more complex field theory, which include a) the need to physically justify a continuum of more than four (real) dimensions; and b) the problem of singularities vs. boundary conditions.

To obviate the idea of space as requisite to a Machian model of inertia, we suggest that time is an *n*-dimension analytically continuous metric; and, string theory principles of 0 and 1 dimension fundamental structure (singularity plus time as a scale invariant metric over *n*-dimension Riemann surfaces) eliminate the need to specify boundary conditions. We find that the logically simplest relativistic field theory is in complex Hilbert space, *n*-dimensional continuous ($n > 3$) and dissipative.

The interested reader is invited to read the research leading to these conclusions at home.comcast.net/~thomasray1209/site