Paper Title: From Reductionism to Emergence: Science Takes A Cooperative Turn
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Paper Abstract:
The present essay explores the implications of the claim that the reductionist program in science has reached the stage of diminishing returns and is now giving way to the emergentist approach. This development has been particularly acute in physics, where it is exemplified by the continuing debate between the two Nobel laureates, Philip Anderson, arguing for emergence, and Steven Weinberg, espousing reductionism.

Based on the work done by Weber, Whitehead, Habermas, Toulmin, and Wilber, the essay situates reductionism in the context of modernity, the latter being characterized by the differentiation of the cultural value spheres: art, morals and religion, and science. The expressive-aesthetic sphere is described in "I" language, the moral-religious sphere in "we" language, and the objective-science sphere in "it" language, which in science appears to privilege reductionism as the explanatory mode. Despite the fact that for the last 400 years reductionism has been quite successful in explaining the behavior of the natural world, lately there has been a growing realization of its shortcomings. These include difficulties with constituent reductionism as one delves into the subatomic realm described by quantum mechanics and relativistic physics, as well as the removal of the observer from the domain of nature that we endeavor to understand. The greatest strength of reductionism is in dealing with linear systems, but much of nature is not linear, including most of what is really interesting in the world. Progress in solving nonlinear equations has come only in the last 50 years with the advent of computers, allowing us to study such phenomena as emergent structures, chaos, tipping points, spontaneous pattern formation, synchronization, and coherence.

In the last part of the essay, I suggest, by analogy with cooperative phenomena in nonlinear science and as an extension of an apparent evolutionary trend, that miracles be redefined within the context of panentheism, as human cooperative phenomena which ultimately may result in radical freedom from physical limitations. To achieve cooperative, participatory, and coherent modes of consciousness, one may employ meditative and contemplative techniques that facilitate ego transcendence. After all, one characteristic of the ego self is the refusal to follow inner guidance. Without the latter one cannot become synchronized with the deeper rhythms of reality.

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Dr. Christopher Jargodzki (Jargocki) was born and raised in Poland, studied at the University of Warsaw, and received his Ph.D. in quantum field theory from the

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Paper Text:

INTRODUCTION

In *The End of Science: Facing the Limits of Science in the Twilight of the Scientific Age* (24), John Horgan argued that science was in a sense a victim of its own success: that all the really interesting and soluble problems have already been solved and all that remained was to fill in the boring details. The book hit a nerve, and the storm of controversy that followed has contributed to the "culture wars" that were raging through the 90's. One of the most eloquent responses was given by Robert Laughlin, a Stanford University theorist who shared a Nobel Prize in 1998 for discoveries in condensed-matter physics, and David Pines, a theorist at the University of Illinois and Los Alamos National Laboratory. In an article provocatively entitled "The Theory of Everything," published in the January 4, 2000 issue of the Proceedings of the National Academy of Sciences, they responded that "Horgan's book might more properly have been called *The End of Reductionism,* for it is actually a call to face the truth that in most respects the reductionist ideal has reached its limits as a guiding principle (…) The end of reductionism is, however, not the end of science, or even the end of theoretical physics (…) The central task of theoretical physics in our time is no longer to write down the ultimate equations but rather to catalogue and understand emergent behavior in its many guises, including potentially life itself."

Indeed, in a clash of scientific cultures, physics departments have frequently become split between the "squalid-staters," from "squalid-state physics," Murray Gell-Mann's pejorative appellation for solid-state physics, and the "superstringers," a less than flattering term for string theories. The latter, quantum field theorists who try to achieve the ultimate in reductionism – reduce all physical reality to tiny strings and membranes vibrating in 10 or even 11 dimensions, have created a culture that is openly disdainful of experiments, reminiscent of Einstein's statement, "In a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed." Despite the claims that "superstring theory is the language in which God wrote the world," there is a palpable feeling of malaise in the particle physics community today. Theorists continue to make predictions but they are usually wrong or not yet testable.

After a review of modernity, and reductionism as its typical stance, we come to emergentism and the main thesis of this paper, namely that nature comes closest to miracles in its emergent synergistic behavior. This may seem like an unusual claim. After all, publications dealing with the science-religion interface are typically filled with rarefied discussions of high-level theory like the cosmological anthropic principle, quantum indeterminacy or the collapse of the wave function. Experimental materials science is not what generally comes to mind when thinking in terms of the classical theism vs. panentheism debate but that is where the emergent synergistic behavior is most easily seen.

MODERNITY ON ENDLESS TRIAL[1]

There is arguably no better guide to the treacherous currents of modernity than Stephen Toulmin's *Cosmopolis: The Hidden Agenda of Modernity.* The origins of the reductionist program, imbedded in the Cartesian-Newtonian paradigm, can be traced back to the time "early in the 17th century, when Descartes persuaded his fellow philosophers to renounce fields of study like ethnography, history, or poetry, which are rich in content and context, and to concentrate exclusively on abstract, decontextualized fields, like geometry, dynamics, and epistemology" (Toulmin , p. X). Early modernity "set aside the tolerant, skeptical attitude of the 16th century humanists, and focused on the 17th – century pursuit of mathematical exactitude and logical rigor, intellectual certainty and moral purity" (Toulmin , p. X). To non-Western observers what impressed above all about this European pursuit was its ability to create power, power over other human beings through military domination and power over nature, both practical in terms of the capacity for economic production, and intellectual in terms of the capacity for prediction and detailed understanding (Elvin 210). In fact, understanding a thing became synonymous with controlling it. The competition for power was characterized by a far-reaching rationality of means. Despite extraordinary advances in many fields of human endeavor, according to the critics it was ultimately a rationality in the service of madness. Certainly, in Toulmin's view, the modern vision fueled the delusion that human nature and society could be fitted into precise and manageable rational categories.

Following various scholars, from Max Weber to Jürgen Habermas, we could tighten our terminology and say that modernity may be characterized by "the differentiation of the cultural value spheres," which especially means the differ-entiation of art, morals and religion, and science. As science became increasingly dominant, it challenged the medieval epistemological pluralism given perhaps its clearest expression by such Christian mystics as St. Bonaventure and Hugh of St. Victor: every human being has the eye of flesh (empiricism), the eye of mind (rationalism), and the eye of contemplation (mysticism). In this scheme science is relegated to the bottom rung, a role that modern science has utterly refused to accept. According to Ken Wilber, the most translated and perhaps the most prolific American philosopher living today, each of the cultural value spheres – art, morals, and science; or in the Platonic ontology the Beautiful, the Good, and the True – "*has a different type of language*. The expressive – aesthetic sphere is

described in "I" language. The moral – ethical sphere is described in "we" language. And the objective – science sphere is described in "it" language (Wilber 1998, 50). What Wilber refers to as the disaster of modernity involved, in his view, some of modernity's differentiations going too far into a specific set of *dissociations:* "The subjective and interior domains – the I and the WE - were flattened into objective, exterior, empirical processes" (56), since modern empirical science has largely rejected the reality of the interior domains. It may be helpful to know that Wilber, deeply influenced as he is by both Neoplatonism's Great Chain of Being and Whitehead's process philosophy, thinks of matter not as the lowest rung in the Great Chain (actually Nest in his conceptual system) of Being, but as the *exterior* form of every rung: matter and consciousness are the exterior and interior of every occasion. It follows that to him the relation of science and spirituality is grounded in the actual relation of any interior realities to exterior realities.

Wilber's analysis of the predicament of modernity echoes Max Weber's interpretation of the history of the West as characterized by the progressive removal of mind, or spirit, from phenomenal appearances, in short the disenchantment of the world (cf. Schiller's Entgötterung der Natur, the "disgodding" of nature). No wonder that, as Whitehead famously lamented, reality became "a dull affair, soundless, scentless, colorless; merely the hurrying of material, endlessly, meaninglessly."

No treatment of the modern mindset would be complete without mentioning "the fallacy of misplaced concreteness," the term coined by Whitehead for mistaking an abstraction for a concrete fact, a mistake that in his opinion derailed Western philosophy. Sir James Jeans summarizes it perfectly: "The essential fact is simply that *all* the pictures which science now draws of nature, and which alone seem capable of according with observational fact, are *mathematical* pictures (…) They are nothing more than pictures – fictions if you like, if by fiction you mean that science is not yet in contact with ultimate reality (…) We are still imprisoned in our cave, with our backs to the light, and can only watch the shadows on the wall" (qtd. in Wilber 1984, 10).

REDUCTIONISM AND ITS DISCONTENTS

It is often said that for the last 400 years science has advanced by reductionism, a theory that all complex systems can be completely understood in terms of their components or in terms of a simple set of laws. It's hard to disagree with this assessment. Since the days of Descartes, Galileo, and Newton, the reductionist program has been surprisingly successful in finding explanations for the behavior of the natural world. Certainly the Nobel prizes in science have almost invariably gone to those who followed the reductionist approach. How then do we square this with the fact that the academy today is seized by a holy enthusiasm over emergent phenomena and nonlinear science? This question needs to be explored if only to relieve a sense of cognitive dissonance.

Let us start with a train of thought that is both psychologically compelling and also related to our discussion of modernity. In the words of Ernest Gellner, "Reductionism, roughly speaking, is the view that everything in this world is really something else, and

that the something else is always in the end unedifying (…) [Reductionism] is rooted (…) not in the nature of things, but in *our* ideal of explanation. Genuine explanation (…) means subsumption under a structure or schema made up of neutral, impersonal elements. In this sense, explanation is always "dehumanizing", and inescapably so" (107). It offends our sense of dignity, especially when presented in the form of a "nothing – but" claim, e.g., living beings are "nothing but" collections of molecules. This example of *constituent reductionism* is actually rather crude for it leaves out the intricate relationships among the molecules that are needed for an entity to be alive. A stronger claim is Marvin Minsky's assertion that human beings are "just computers made of meat." This can be offensive or not depending on how one views "meat." If one has been enculturated into seeing the world as disenchanted, a practically default option within modernity, probably not very highly. But what if one were to follow Wilber in viewing matter as simply the exterior form of every occasion? Then one would rediscover what Heraclitus said twenty-five centuries ago, "Nature loves to hide." Let me elaborate. In order to conform to standards of objectivity, the scientist needs to subtly alter her consciousness and assume a distancing orientation toward the object of study. Sympathetic immediacy, inherent in participatory consciousness, would presumably interfere with this task. Is there a price to be paid for objectivity? That partly depends on whether one regards consciousness as an active force, a view that is being tested in studying the effects of intercessory prayer. But the price to be paid, according to Erwin Schrödinger, is even more fundamental. In *Mind and Matter* (1958) he uses the term "The Principle of Objectivation" to describe what happens when "without being aware of it and without being rigorously systematic about it, we exclude the Subject of Cognizance from the domain of nature that we endeavor to understand. We step with our own person back into the part of an onlooker who does not belong to the world which by this very procedure becomes an objective world" (qtd. in Malin 102). In Schrödinger's view this procedure entails a certain simplification: When the entities in nature are treated as objects, not all of their characteristics show up. The physicist Shimon Malin goes one step further. Following Whitehead, he states "An object is how an entity appears to us. Its appearance as an object is its *public* character. If an entity cannot fully reveal itself as an object, it must have another, *private* aspect, which is what it is in and for itself" (135). Here those who are inclined to take the perspective of transpersonal psychology might offer a qualification: From the viewpoint of participatory consciousness the private aspect of an entity is partly revealed as Spirit shining through, in glimpses available to those who at that moment do not wish to treat anything or anyone as an object. Ego defenses drop and one gets a glimpse of what lies behind the veil of appearance. Would this make science epistemologically suspect? Not necessarily. It would, however, make science and spirituality complementary in that the public and the private aspects of an entity would be revealed to us in different states of consciousness, distancing vs. participatory, a thesis Charles Tart, one of the founders of the field of transpersonal psychology, has advocated now for several decades with his concept of state-specific sciences. Aldous Huxley made a similar point even earlier, "It is a fact, confirmed and reconfirmed by two or three thousand years of religious history, that Ultimate Reality is not clearly and immediately apprehended except by those who have made themselves loving, pure in heart, and poor in spirit."

Let us now touch on some of the more mundane difficulties with one kind of reductionism, constituent reductionism, at the most fundamental but still experimentally accessible level in science, the level of nuclear and subnuclear physics. At this level we need to employ both quantum mechanics and relativistic mechanics. These imply that one cannot unproblematically say, for example, that the nucleus of carbon (C-12) is *composed* of six protons and six neutrons. If that were true, the mass of the nucleus would be equal to the sum of the separate masses of its protons and neutrons. But actually it is less, due to the negative binding energy that is equivalent to *mass defect*. The situation is even more counterintuitive at the level of a single proton. We speak loosely of a proton as being as being composed of three quarks, but if you look closer at a quark, you will find it surrounded with a cloud of "virtual" quark-antiquark pairs and other particles. For a brief moment the quarks will bind into protons, and so then we could say that the quark contains protons (Weinberg 112)! Evidently the naïve mechanistic view in which protons and neutrons are regarded as the building blocks of nuclei, and quarks as the building blocks of protons and neutrons breaks down at the level of subatomic physics. Constituent reductionism becomes even more questionable from the point of view of quantum mechanics for then we have the problematic situation of probability waves becoming building blocks! Moreover, as pointed out by Harold Morowitz, this procedure presents us with an epistemic circle (8-9): As we try to explain the mind in terms of the brain, the brain in terms of its underlying biochemistry, the latter in terms of atomic physics, and atomic physics in terms of quantum mechanics, we return to the mind as a primitive component in at least some interpretations of quantum mechanics.

EMERGENCE AND NONLINEAR SCIENCE

Reductionism, for all its successes in the physical sciences, tends to promote the view of reality as consisting of isolated and disconnected components. In the words of Arthur Eddington, "We were used to thinking that if we knew one thing, we therefore knew two, because one and one are two. We are discovering that we must learn more about the and." Even in a relatively simple situation at the quantum level, Bell's Theorem already shows that two subatomic particles exhibit a significantly greater degree of correlation than allowed by classical physics, as if they were engaging in a conspiracy to cooperate. The degree of cooperation is even greater in superconductive materials where at low temperatures the billions of electrons that constitute the current behave as one, moving in a highly correlated and organized pattern. The BCS theory, proposed by Bardeen, Cooper, and Schrieffer in 1957, envisions electrons joining in pairs due to the mediating action of the crystal lattice, rather unusual for two negatively charged particles, at which point they can move without resistance through the lattice.

If reductionism is associated with the view that the whole is equal to the sum of its parts, as is true for linear systems, emergent and cooperative phenomena display *synergy,* i.e., for them the whole is greater than the sum of its parts, as is characteristic of nonlinear systems. Much of nature is not linear – including most of what is really interesting in the world. Examples include *emergent structures* (protons, neutrons, nuclei, atoms, solitons, instantons, black holes, tornadoes, tsunamis, schools of fish, cities), *filamentation* (rivers,

bolts of lightning), *chaos* (the butterfly effect, strange attractors, turbulence), *tipping points, spontaneous pattern formation* (the Gulf Stream, hurricanes, ecological domains, natural languages), and *synchronization* (Huygens' pendulum clocks, flashing of Indonesian fireflies, circadian rhythms). Nonlinear equations are notoriously difficult to solve by hand which goes a long way toward explaining why for over 300 years reductionism was the only game in town. Progress in solving nonlinear equations has finally come in the last 50 years with the advent of computers.

At this time there is still no agreement as to the precise definition of emergence. For Robert Laughlin the property one is calculating is emergent if it is robustly insensitive to details. In this sense the precise arrays found in crystals are emergent because it is not necessary for molecules to move in a special way for the crystallization process to occur. In Laughlin's view this implies that high-level laws are, in a sense, more important than the laws that govern lower levels of organizational complexity: "The laws of quantum mechanics, the laws of chemistry, the laws of metabolism, and the laws of bunnies running away from foxes in the courtyards of my university all descend from each other, but the last set are the laws that count, in the end, for the bunny" (Laughlin 2005, 219). This statement echoes what Philip Anderson, a Nobel Prize winner for condensed matter physics, has asserted in his now classic paper, "The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe" (Anderson 1972). We cannot reconstruct the universe because the number of possible emergent structures at each level of, say, the biological hierarchy leads to what mathematicians call a 'combinatorial explosion.' For example, throughout the long history of life on earth, most of the possible protein molecules have never been constructed and never will be. According to the complexity theorist Alwyn Scott, "It follows that biological science differs fundamentally from physical science, which deals with *homogeneous* sets having identical elements. (…) In the biological, cognitive, and social sciences, on the other hand, (…) experiments are necessarily performed on *heterogeneous subsets* of the classes of interest. Because the elements of heterogeneous subsets are never exactly the same, it follows that experiments cannot be precisely repeated" (57). Based on this type of reasoning, Laughlin contends that "much of present-day biological knowledge is ideological. A key symptom of ideological thinking is the explanation that has no implications and cannot be tested. (…) Evolution by natural selection (…) has lately come to function more as an antitheory, called upon to cover up embarrassing experimental short-comings and legitimize findings that are at best questionable and at worst not even wrong" (Laughlin 2005, 168).

MIRACLES AS COOPERATIVE PHENOMENA?

> Nature is a collective idea, and though its essence exist
> in each individual of the species, can never its perfection
> inhabit a single object
> -Henri Fuseli

The growing sense that reductionism has reached the stage of diminishing returns, particularly in physics, is aided by the postmodern skepticism toward grand

metanarratives, and the consequent popularity of pluralism. According to its advocates, no unified account of reality seems possible or even desirable. Any attempt at a unified picture of reality today almost smacks of totalitarian tendencies. This trend goes hand in hand with the movement away from classical theism and toward panentheism. Indeed, panentheism is more emphatic in its portrayal of immanent divinity as a source of novelty and creativity, features that are also displayed by emergent phenomena.

As one ascends the levels of organizational complexity, from inanimate matter to multicellular organisms, one clear trend is the growing freedom from physical limitations. Just a few examples will suffice. Living organisms *locally* violate the trend toward increasing entropy by maintaining themselves as islands of order. Warm-blooded animals, such as mammals and birds, maintain a constant body temperature regardless of the temperature of the surroundings. We differ from animals in our relative freedom from the tyranny of instinct. With our technology –balloons, airplanes, and rockets – we easily transcend the limitations of the law of gravity *without* violating it. The Meissner effect, the spontaneous levitation of a small piece of superconductor placed above the pole of a magnet, is another example of what one might appropriately call a physical miracle. As Robert Laughlin expresses it, "the tendency of nature to form a hierarchical society of physical laws is much more than an academic debating point. (…) It renders the most fundamental laws, whatever they are, irrelevant and protects us from being tyrannized by them" (Laughlin 2005, 8).

How is this related to the question of miracles? Here I follow Whitehead's insight, as summarized by Wilber, "You must start at the top and use the highest occasions to illumine the lowest, not the other way around, which of course is the common reductionist reflex. So [Whitehead] said you could learn more about the world from biology than you could from physics; and so he introduced the organismic viewpoint which has revolutionized philosophy.[2] And he said you could learn more from social psychology than from biology, and then introduced the notion of things being a society of occasions (…) you first look to the highest levels for the general principles of existence, and then *by subtraction* you see how far down the hierarchy they extend" (Wilber 1985, 262-3). In this sense one could say that, for instance, the Heisenberg Uncertainty Principle represents all that remains of God's radical freedom on the physical plane. Hence, as Huston Smith pointed out, higher levels of being can run circles around lower levels of being, something that doesn't bode well for the scientific research into prayer. To return to the main line of the argument, all of science could be regarded as what I call a *Whiteheadian remnant* of theology. For example, the nonlinear science of synchronization and coherence might be viewed as a Whiteheadian remnant of synchronicity. All of the above suggests a new definition of miracles, one more in keeping with panentheism than classical theism: miracles as human cooperative phenomena which, without denigrating physicality, ultimately result in radical freedom from physical limitations. This approach goes beyond John Polkinghorne's emphasis on miracles as signs, although certain synchronistic events interpreted as signs could then be regarded as low-grade miracles. The new definition is purely exploratory at this stage, and is left intentionally vague. Considering that the phenomena in question are far from being understood, any attempt at clarity would be premature.

We are reminded here of Arthur C. Clarke's Third Law, "Any sufficiently advanced technology is indistinguishable from magic." Let me rephrase it as "Any sufficiently advanced spiritual technology is indistinguishable from miracles." As the dominant state of human consciousness at this time is still sadly characterized by separation and distrust rather than union, and by distancing and incoherent modes of awareness, before we follow Hume in claiming that miracles must of necessity violate the laws of nature, we need to display some humility and admit to ourselves that we have little experience with what can be achieved through cooperative, participatory, and coherent modes. "If two of you agree on earth concerning anything that they ask, it will be done for them by My Father in heaven. For where two or more are gathered in my name, I am there also" (Matt 18:19-20). Doesn't this famous Gospel passage describe what can be achieved with spiritual coherence? [3] The latter would be analogous to the way, for example, that laser light is coherent and what amazing power can be achieved through coherence.

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As Philip Clayton has noted in his treatment of miracles, in panentheism one possibility is that "God is always and at all times available for those who know who know how to plumb the depths" (7). To translate this into the language of transpersonal psychology, perhaps transcending one's ego is a necessary condition before one can enter into a cooperative relationship with the supportive web of life, or immanent divinity if you will. According to this non-interventionist explanatory mode, even if the overall cosmic optimality is difficult to discern, we can always find an optimal path through life on which we are in sync with the cosmic flow of events (Jargodzki 1993, 1997). How is this achieved? By employing meditative and contemplative techniques that facilitate ego transcendence. After all, one characteristic of the ego self is the refusal to follow inner guidance. But without the latter one cannot become synchronized with the deeper rhythms of reality.

NOTES

1. The heading is borrowed from the title of Leszek Kolakowski's book
2. In defense of physics: certain phenomena which are hopelessly muddled in biology can be understood very clearly in physics, even if only in a simplified form
3. There are intriguing hints that illness may be interpreted as a loss of biological coherence (Ho 135)

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