An Argument for a Second-Order Cosmology

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"Problems cannot be solved by the same level of thinking that created them."
—Albert Einstein

Abstract

This paper proposes the feasibility of a second-order approach in cosmology. It is intended to encourage cosmologists to rethink standard ideas in their field, leading to a broader concept of self-organization and of science itself. It is argued, from a cognitive epistemology perspective, that a first-order approach is inadequate for cosmology; study of the universe as a whole must include study of the scientific observer and the process of theorizing. Otherwise, concepts of self-organization at the cosmological scale remain constrained by unacknowledged assumptions and biases. Examples of limiting notions are discussed in the context of alternatives. To include the role of the theorist does not mean reducing science to subjective or sociological terms. On the contrary, second-order science would provide a more complete portrait of nature. The work of cosmologist Lee Smolin is discussed as a candidate example of second-order cosmology.

Introduction

The awareness of awareness presents a familiar "second order" to the primary external focus of human cognition. As a form of cognition, science could be similarly reflexive, complementing its usual subject-object orientation. Dropping the traditional unilateral relationship to the material world could open up new avenues of research in physics and cosmology.

The distinction between first and second order is imported from cybernetics[1], which is concerned with circular processes of control involving goals and feedback. (Heylighen 1979). Though it does not widely appear in fields not concerned with such processes or the participatory role of the observer, the terms can be adapted to physical science. Accordingly, I propose that first-order science studies the object by excluding the subject, while second-order science also studies the role of the subject/theorist in formulating the theoretical object, which involves an interactive control process. Two background questions to keep in mind are: in what situations should natural physical systems be considered cybernetic systems, and when is it appropriate to consider the scientific observer's influence on the system, including conceptual as well as physical influence?

While physics typically deals with systems from which the observer stands apart, unconsidered, study of the universe as a whole must by definition include the observer, at least as a physical presence. Cosmology is a highly theoretical science, dependent on long chains of inference often based on the evidence of a few photons of light. Its speculations can border on metaphysics, and its methods are sometimes controversial, as in the use of anthropic reasoning. It is often concerned with fundamental questions, such as the self-organization of the universe and the ultimate horizons of knowledge. For such

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[1] The French term *cybernétique* was apparently coined by Ampére in 1834, in a treatise on government, based on Plato's use of *kybernetikes*. The English *cybernetics* was introduced by Norbert Wiener in 1948. [Wikipedia: cybernetics]

reasons, the theorist is highly involved conceptually and it is appropriate to include analysis of this involvement in the science itself.

An obvious concern, however, is whether a second-order approach is feasible without obstructing the primary aim to study nature. I answer in the positive, adding that first-order approaches have clarified physical systems in select ways at the cost of obfuscating them in others. In many situations the science would be improved by deeper analysis of the theorist's involvement. I hope to convince the reader that a second-order approach is essential in some contexts for further progress. Overall, a second-order science would be a more *complete* science—more, not less, "objective."

A sweeping effect of the Scientific Revolution, nevertheless, was to redefine natural philosophy as first-order science. Though there are relevant historical as well as metaphysical reasons for this, the history and sociology of science must remain largely peripheral to this brief exploration, which will focus on how certain assumptions today may limit thought in cosmology. Following some general topics, I will note a few such assumptions whose exploration might be proper to a second-order science. Then I will examine some of the work of cosmologist Lee Smolin, especially as set forth in his admirable popular book *The Life of the Cosmos*, as a candidate example of second-order cosmology.

What is 2nd-order physical science?

Classical physics is the paradigm of a first-order science, in which the physical world, and not physics or the physicist, is the object of study. This focus reflects the outward focus of the organism motivated to take an interest in its environment, whose cognition is part of its strategy for survival. This very realization, however, establishes a reflexive point of view for theorists, who have the opportunity to consider their own activities in the light of such concepts. And, while individual sciences may adhere to first-order description, the notion of *science* in the large suggests a human enterprise as well as a body of knowledge. On the other hand, one of the ways a given discipline can maintain itself as a first-order science is through the clear delineation of its subject matter in contrast to other specialized disciplines.

Yet, every inquiry leads naturally beyond its borders. Physics is now positioned to struggle with grand questions, such as how the universe as a whole could have arisen. Yet, to answer such questions scientifically may require more than extending and joining existing bodies of knowledge, and more than a new theory or ontology, framed within current terms. The grand questions concern not only what exists (the object) but also how the theoretical observer (the subject) relates to it. For, in the case of the universe as a whole, the observer can no longer be presumed to stand outside the system observed. At the other end of the size scale, the Measurement Problem in quantum physics seems also to implicate the observer's participatory role. Ultimately, both call into question the traditional separation of subject and object.

Nevertheless, the tendency of first-order science is to maintain a certain closure, so that all questions remain amenable to objective description. This means, for instance, that the participation of the observer is considered only in terms of *physical* effects, as another element of the physical system. A second-order science, in contrast, would explore the role of the observer-theorist *qua* subject. While 1st-order science applies fixed rules and premises, 2nd-order science puts these in play as new "variables."

Reflexive consciousness involves self-reference, mixed domains, differing logical levels. Hence, it notoriously entails paradox and confusion. Its inclusion in mathematical logic spelled the end of the program to formalize all of mathematics. No doubt this is one reason for physical science to avoid self-reference by excluding the subject. This exclusion cannot get around the obvious contradiction of an observer standing outside the universe, nor the complementary recursion of an observer within the observer. A 2nd-order science must steer between these shoals, embracing both subject and object conjointly, in such a way that reduces to the "special case" of a 1st-order description when the object is considered in isolation from the subject. A 2nd-order cosmology would incorporate reflection on its own methodology and primitive assumptions, a practice that was once integral to the study of nature, when science was known as natural philosophy.[2]

One reason the distinction is not more widely used today may be that the concept of *cybernetic system* is difficult to apply outside engineering, biology, sociology, or economics. These areas of study involve agency among and within the objects of study, but do not necessarily include the agency of the theorist in the description of the cybernetic system. On the other hand, studying the concepts and methods used to represent phenomena in theories should be universally meaningful. Accordingly, this inclusion is the sense of "second order" I will focus on. Yet, it may be useful as well in cosmology to consider agency within various self-organizing systems, such as galaxies. It could be interesting to explore how terms such as "allopoietic" and "autopoietic" may or may not apply to such systems. A related question is to what extent inanimate nature is truly "inert" or "passive", as traditionally assumed.

Heylighen (2001: 9) distinguishes two kinds of circularity. Non-linear processes and physical feedback loops involve a single logical level, while paradoxes of self-reference have to do with multiple levels. Hence, scientific intervention may affect the phenomenon physically but also conceptually. The first possibility can be accommodated within 1st-order description, but not the other. Quantum measurement is an example of interaction with physical effects. However, the *interpretation* of quantum measurement is controversial even among physicists, so that it is also a 2nd-order question.

2nd-order physical science should not be restricted to physical effects. Some notions drawn from 2nd-order cybernetics may transfer generally to physical science.[3] For instance: the notion that science can be usefully expanded by including the observer as part of the system; that 2nd-order theory can direct how 1st-order theories should be used; and that 2nd-order science could be more accurate than 1st-order science. (Umpleby 2011).

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[2] Early Greek philosophers had developed a number of second-order concepts. Greek thought was characterized by a novel reflection on its own innovations, which included deductive method and axiomatic proof in mathematics, geometrical models in astronomy, and causal theories of disease in medicine. (Schiefsky 2012: 1). Even throughout the middle ages, there was little separation of 1st-order and 2nd-order concerns.

[3] Kenny (2009: 100) cautions against the tendency even of 2nd-order cyberneticists to backslide into a 1st-order approach. This includes the danger that the meta-perspective takes on the same overconfidence characterizing 1st-order science, or objectifies its domain in the manner of naïve realism.

As a theory of information and regulation, cybernetics might help to clarify physics concepts such as "information" and "entropy", which currently exclude the role of the observer.

Science as cognition

Science is viewed here as a form of human cognition, affirming the basic premise that *all* cognition necessarily involves both subject and object. (One speaks of subject and object in the human context, but the same conjoint relationship may be expressed in terms of organism and environment, for example.) Like cognition generally, science is an interactive process, which nevertheless tends to focus outwardly on the object—the world. By convention, 1st-order science does not consider its own modeling processes, nor the agent doing the modeling, as part of the system modeled. Despite enormous successes, there are drawbacks to this restrictive approach, which deals with artificially defined systems to which human agency remains extraneous. Despite the external focus, the actual objects of scientific study necessarily are various scientific constructs, whether experimental or theoretical. In that sense, science is a self-contained enterprise that only obliquely refers to nature. This by no means sets it apart from ordinary cognition, insofar as the organism may also be said to deal immediately with its own processes, and only indirectly with external reality.

Science is both an organ of cognition and a social system. It is guided both by the reality of nature and by human needs and desires. Certainly most physical scientists would insist that it is as objective as humanly possible. They might concede that the role of theory is model making or prediction, yet as human beings they likely care about truth and reality as well. As components of social systems, moreover, scientific institutions and individual scientists may defend against threats to their own professional goals and to the scientific enterprise.

Like other cognition, science tends to relate to its constructs as though dealing directly with the world itself. While this strategy is no doubt adaptive, the human organism has evolved a secondary capacity, to address problems that arise from such projection—whether personal, social, or scientific. This capacity is the awareness that we are aware, and that our perception is not an open window on the world but mediated by cognitive processes that reflect not only structure in the world but also the structure, needs, and motivations of the organism. This second-order awareness has obvious advantages for a social creature, to temper natural impulses and reactivity based on naïve faith in the fidelity of perception. It also has advantages for a technological creature, since it establishes an inner workspace for imagination, language, culture, and tool making. Since science and technology are developments of this inner workspace, it is reasonable to challenge their exclusion of subjectivity.

While it appears that the world is knowable (and livable) because nature obeys rational principles and hierarchical laws, it is reasonable to wonder to what extent these reflect human preferences and thought patterns. The ongoing task is to sort out what is intrinsic to the world from projections upon it. In one sense, 1st-order science claims to have done this long ago, simply by eliminating secondary qualities from its ontology and subjective elements from its method, as originally prescribed by the Enlightenment fathers. Yet there may be subtler ways in which the scientist remains embedded in cognitive biases that shape the terms of scientific investigation.

Knowing the object always involves a knowing subject. 1st-order science deals with the paradox of knowing "the world in itself" by attempting to bracket the observing subject, as an insubstantial fly on the wall outside the system observed. However, while physics regularly treats of idealized systems, isolated from each other and from the physical influence of the observer, there are no such things in nature. Moreover, "systems" can only be identified at all in accord with human purposes. How nature carves itself is another question. While it is the question ostensibly asked by 1st-order science, a more adequate answer should be possible by considering the purposes behind the guise of objectivity. Current approaches, still based on mechanism, treat nature in terms that are clearly matters of human definition. Yet, it may be meaningful to ask: how, and in what sense, might nature *define itself*? The question bears promise for understanding not only nature but also the process of theorizing.

Physical science rarely asks such questions because of a long-standing prejudice in favor of the active "spiritual" (read: disembodied) nature of the human agent, and against active powers of agency within nature. Consistent with the mechanist metaphor, physics has traditionally dealt with inorganic matter as passively deterministic, lacking inherent powers of self-organization. This bias goes back to early Greek thought, to the religious origins of science, perhaps even to the genetically conditioned male psyche. It may be an adaptive trait, insofar as it serves technical mastery. The fact, that the 1st-order approach *works* to produce the technological miracle, may be a strong argument not to muddle science with self-reference or too much philosophy. However, the 1st-order approach does *not* work uniformly, even in science. In particular, it reaches limits in cosmology, in quantum theory, and in questions of self-organization generally. It may also have reached its limit as a strategy of the species, to the extent it creates a dangerously distorted relationship to nature.

A scientific consequence of the exclusion of the subject from 1st-order science is that *agency* within nature remains problematic and neglected. For, the one-way relationship of subject to object means that the object is no subject or agent. Because we are used to identifying agency with human or divine actors, or at least with creatures manifesting intentionality, we tend to lack a category of agency that is independent of these references. A spinoff of a more reflexive science could be an expanded concept of agency and a broader perspective on self-organization.

Historical prolegomenon to a 2nd-order physical science

In its origins, science was shaped by belief in a creator God, by medieval interest in machines, by discoveries of new lands and natural riches, and by ancient Greek rationalism. Such factors conspired toward a mechanistic view of the natural world, as the object of a one-way relationship. The scientific observer was implicitly external to the world investigated, just as the Creator was separate from his Creation, and the mind from the objects of its attention. Scientific laws were interpreted as divine decrees over a subservient nature. Accordingly, the scientific object of study became the "isolated system", a theoretical artifact defined and governed by mathematical laws presumed to transcend it. These were usually parameterized as functions of "time", defined by a clock also artificial and external to the system. In the large, such idealized elements functioned much as other cultural artifacts do: namely, to redefine the world in human terms. (Bruiger 2006). The fact that no natural system is *actually* well-defined or isolated from the rest of the universe could be disregarded in view of success at predicting the course of phenomena that corresponded well enough to definitions to allow the formulation of mathematical laws. A price was paid, however, since for two centuries *only* such phenomena were then sought out for study.

The observer too was standardized and interchangeable, through an exclusive focus on "primary qualities"—ultimately, variables of position and their time derivatives. Observation was essentially visual, despite the fact that notions such as "force" and "temperature" refer to other sense modalities. Ideally, the observer should have no physical influence on observation. However, astronomical distances could not be measured with rulers but depended on information remotely transmitted by light. The finite rate of its transmission posed problems over great distances, especially for rapidly moving sources, leading eventually to the theory of relativity. This was the first indication that the physical circumstance of the observer needed to be taken into account. The second came soon after, with quantum theory, which confronted the finite texture of light.

Further developments helped to undermine traditional expectations: the development of cybernetics, the new disciplines of complexity and chaos, and of high-energy and low-temperature physics, and new understandings in biology, ecology, and brain science. These suggested limits of notions like the isolated system, hinting not only at the scientist's participation, but also the participation of all things in all other things. Modern physics concepts such as entanglement, decoherence, and non-locality point to an essential wholeness even in the non-living world. While the advance of theory and technology expanded the range and sensitivity of observation, there was still no call for a 2nd-order approach, featuring the conceptual involvement of the theorist in the scientific narrative. Physics could be reflexive on the level of physical influences, channeled into 1st-order description, but any other meta-analysis was generally left to philosophers.

This situation changed with the merger of fundamental physics and cosmology. The very meaning of "isolated system" changes when the universe is the only truly isolated system. Traditional notions concerning observation and the reality of objects are challenged by quantum phenomena. In both realms, more is at stake than the *physical* inclusion of the observer. For, there are persistent conceptual difficulties in quantum theory, the Standard Model of particle physics, and the Big Bang model of cosmology. These challenges include the measurement problem, the enormous discrepancy between predicted and observed values of the "vacuum energy", various "fine-tuning problems", and the related mystery of the universe's entropic history (which may involve "dark energy"). They suggest that physical science could profit by reclaiming some of the duties heretofore abandoned to philosophy. Indeed, this is already happening in such venues as the Santa Fe Institute and the Perimeter Institute, where disciplines cross-pollinate, and in such popular formats as Edge and Youtube, as well as in the writings of scientists for popular consumption.[4] It is already happening in the theoretical work of cosmologists such as Lee Smolin. Yet, with notable exceptions, it has not yet generally penetrated academia.

The closure of 1st-order science

First-order description is strictly an account of events in the physical world. While this closure obviously serves to keep physicists within the bounds of physics, it also represents a ceiling to the kind and the terms of reflection that may be undertaken. Symptoms of this ceiling include what Kenny (2009: 103) calls "epistemological cheating"—the recycling of a domain of description to serve as its own cause or rationale. For instance, though the physical world may be cognized differently by various actual or theoretical organisms, we take *our* way of cognizing it as the *actual* world, which is then (circularly) supposed to be the objective cause of our cognition and that of other creatures. Our way of telling the story of the world serves as the standard reference, the transcendent domain from which are derived all possible other versions. It is commonly assumed that mathematical theories of physics describe this domain. But that article of faith simply defers to another: the transcendent reality and universality of mathematics, which (whatever else it is) is another construct.[5]

The notion of indefinite theoretical possibilities other than what we perceive entails a need to position our human selves as cognitive agents within this "landscape" of possible worlds. Toward that end, for example, a typical 1st-order account would focus on objective events leading to the type of universe harboring observers. The cognition of observers simply adapts to the conditions of such a universe and plays no physical role in setting them. (Hartle 2010: 15-16). Any other kind of role is not discussed, so that despite reference to observers it remains a 1st-order description. Smolin (1997: 266) comments on this approach: "it is possible to perceive the world in classical terms because it is highly organized… There must be something essential… about the fact that the world is complex." One might add: there must be something essential (to the classical view) about how the human psyche perceives the world; and there must be something to be gained *scientifically* by considering how evolutionary history shapes scientific thought and its categories.

The recognition of mathematical possibility beyond what is seen to exist has often led to the discovery of new phenomena. Perhaps, analogously, the recognition of broader "cognitive possibility" could also lead to new discovery. Physics is highly mathematical, and it is reasonable for physicists to believe in the guidance of mathematics. Yet,

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[4] Perhaps one reason why scientists are motivated to write such books, ostensibly to share their work with a wider audience, is also to provide a forum for their more philosophical views, which would be considered out of place in the 1st-order accounts of journals.

[5] Of course, many mathematicians and physicists (beginning with Plato) insist that mathematics *is* a transcendent realm, with a special relationship to physical reality, such that even aliens would recognize the same mathematical truths that we do. (Tegmark 2007). Yet, clearly the transcendent status of mathematics is the notion of an embodied creature. How aliens might view this situation, or what their mathematics might include, cannot be known a priori.

mathematics does not usually take us outside the first order.[6] If physics is a form of cognition, then perhaps it is also reasonable to believe in the guidance of cognitive theory, evolutionary psychology, and what might be termed abstract epistemology.

Another effect of 1st-order closure involves the faith that we should be able to understand complex, non-linear processes in terms of familiar deterministic models. Self-organizing processes are presumed to involve extensions of known reductionist mechanisms. Yet, the search for the simple linear relationships behind such models developed for historical more than logical reasons: that's what could be done with the intellectual resources available. We now have access to vastly improved resources—the digital computer, in particular—that enable the study of non-linear processes and greater complexity. We are only beginning to entertain a mentality to match.

A science of questioning assumptions

A 2nd-order science may escape 1st-order closure by considering certain intuitive notions, which Gerald Holton called "thematic content." These are "preconceptions that appear to be unavoidable for scientific thought, but are themselves not verifiable or falsifiable" (Holton 1988: 13). They form a third "dimension" of scientific practice, beside the usual analytic and empirical aspects characterizing 1st-order science. Many such thematic elements were already incorporated in early Greek thought—such as reduction, invariance, deductive reason, geometric modeling, symmetry, and technological metaphors. (Schiefsky 2012: 3). While some may appear self-evident even today, every identifiable assumption entails alternatives worth considering. A classic example from mathematics is the self-evident truth of Euclidean geometry, alternatives to which were only developed when the parallel postulate was relaxed. In this section I identify, as examples, several such "themata" often associated with 1st-order science.

1. *Reification* is a psychological action that often keeps discussion at a 1st-order level. Processes and relationships are conceived as things, issues are framed in ontological rather than epistemic terms.

2. The *principle of sufficient reason* suggests there should be an answer to every reasonable question about why the world is as it is. Its success in familiar realms bears no guarantee of a priori truth, nor of application in other realms. Similarly, the *identity of indiscernables* depends on the possibility to enumerate all properties or relations shared in common. Yet, an unequivocal list of defining properties or relations is only possible within a deductive system (a model). Leibniz' two principles already assume that the world *is* such a system.

To specify measurable quantities as *the* pertinent variables faithfully representing the real properties of a system (even including the investigating apparatus) begs the question of how well such factors can be separated from each other and from information

[6] The reason, I believe, is that mathematics, in its empirical origins, abstracts general properties of physical reality, and hence generally reflects a first-order point of view. Gödel's theorems are an obvious exception. And, I do not mean, of course, that mathematics would play no role in a second-order science.

that is already presumed irrelevant. (Mets 2012: 183) It may be that the physical variables of a theory are neither exclusive nor exhaustive, or do not even pick out clearly identifiable properties. *Defining* them mathematically, on the other hand, *renders* them definite and complete, masking the ambiguities involved in the experimental or observational set-up, which include shielding, interpretation of signals, statistical spreads, etc. (Cartwright 1999: 152).

3. *Deductionism* is the credo that nature can be formally modeled, even exhaustively, by defined constructs. Reductionism reduces to deductionism, since it reduces reality to defined parts of some model—a deductive system. While such things are not found in nature, their appeal no doubt lies in offering of a complete, certain, and unqualified account—through fiat and logical consistency rather than empirical evidence.

The perennial dream of a completed theoretical science assumes that physical reality is exhaustible in thought, that there must be a bottom to the complexity of matter and an end to inquiry about the fundamentals, if not the details, of physical reality. It assumes that the world is something definite, with a calculable information content, and can be fully captured in mathematical expressions. Though such assumptions may be functionally grounded in our evolutionary history, the question of their truth is appropriate for a 2nd-order science and bears on contemporary issues in cosmology.[7]

4. The *mathematization* of science reflects the fruitfulness of mathematics for the study of nature, so taken for granted that many now assume that physical reality consists literally *of* mathematics. Platonism aside, mathematics is a descriptive tool. The purposes for which it is used, and its syntax as the language of science, influence our concepts of nature and relationship to it. Yet these influences tend to go unrecognized in 1st-order accounts—indeed, within our culture. The assumption that natural reality can be captured in the special idealizations to which mathematics applies is a corollary of the belief that reality can be contained in human definitions at all. There may be a scientific price, as well as a cultural one, to pay for such oversimplifications.

While we marvel at the effectiveness of mathematics to model nature, perhaps the true marvel is the general ability of thought to model the external world at all. A general theory of intelligence might help account for the astonishing effectiveness of mathematics, which would then be situated as one development of a broader evolutionary capacity to model, abstract, and generalize. (Baum 2007).

5. *Computerization* provides not only a powerful new tool for science and society but also the contemporary metaphor of nature itself—a neo-mechanist vision. One function of a 2nd-order science should be to recognize and compensate for the influence of such metaphors, as well as of trends and fads within the scientific community.

The computer is psychologically significant because it translates into technology an age-old dream to directly configure reality. At the same time, like other tools, the computer not only enhances but also channels our perception. It reflects the architecture of human thought, which is obviously shaped by nature. While the discrete states of a computer are held to depend ultimately on quantum discreteness (Penrose 1989: 403),

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[7] Such as the Beckenstein bound, the holographic principle, and the nature of "information."

discreteness is a matter of scale and definition. The computer's *definitional* discreteness is projected back upon nature as a fundamental property. The architecture of human thought, and of the computer in particular, is projected back upon nature as its very organization. A different approach may be required to understand nature's *self*-organization.

6. *Specious improbability.* Many properties of the actual universe, far from equilibrium, appear startlingly improbable as the result of a random shuffle of theoretical parameters. But this impression involves a dubious metaphor, which attempts to assimilate the complexity of the world to artificial situations, such as a role of dice or shuffle of cards. Cosmologists calculate the vanishingly negligible probability that a universe supporting life could arise from randomly chosen values of parameters of the standard model of particle physics or the current model of cosmology. Given *one* universe, however, such calculations seem artificial; the very notion of a randomly generated universe is a theoretical fancy. The question of how initial conditions are "selected" is ambiguous, since it is unclear who or what is selecting. In the literature, sometimes physical processes perform this service, yet sometimes it is the theorist who specifies the initial or boundary condition, as in the running of simulations.

Selection by chance may be likened to the outcome of unstable equilibrium. It seems more reasonable to explain the values of fundamental parameters by looking to *stable* equilibrium—attractor states insensitive to initial conditions. Rather than an explanation designed to overcome specious improbabilities, one should seek a scenario in which all parameters or initial conditions tend toward the state concerned. Moreover, "parameters" must not be seen in isolation; it is the total package that corresponds to the attractor state.

7. *Ceteris paribus* evaluates effects where there are multiple causes, by examining one factor at a time. In scientific application, it is an artifact of experimental method, of artificial situations *designed* to allow one factor to vary in isolation from others. Computer simulation is a logical extension, since factors in a program are controllable by definition. But the universe, so far as we know, is *not* an artifact, not a simulation, and not a laboratory that can be so controlled. Identifiable factors may operate in concert in real self-organizing processes, so that changing one necessarily changes others.

8. *Premise selection*. While there may always be unacknowledged factors at work, no explicit meta-rule guides the selection of basic premises in 1st-order theories. It is possible, for example, to eliminate either time or space from physical description, but only by introducing other concepts subjectively held to be more fundamental. The meaning of that discretionary sense of hierarchy, which makes one concept seem more fundamental or preferable, deserves to be explored. Perhaps there are frank discussions among theorists about the origins of their personal preferences, but these seem to find their way, if at all, only into the popular literature.

9. The concept of *entropy* was devised in terms of useful terrestrial systems. It can be problematic when extended to the universe as a whole, and is sufficiently tricky and context-dependent to warrant rethinking in cosmology. The modern translation of entropy

as *information* seems especially questionable, since information depends on subjects as well as objects.

10. The concept of *reversibility* leads to conundrums such as the arrow of time, or the problem of accounting for why events in the real world are irreversible. Deterministic systems are generally "reversible" simply because their equations are time-reversible. Since there *are* no deterministic systems in nature, the cost of treating nature deterministically is worth exploring.

11. The concept of *order* depends on context and history. A pile of books on the floor may appear disordered, compared to neatly shelved books in alphabetic order. However, the appearance of order is relative to the intentions of agents involved. If the books had been carefully placed on the floor according to their relevance in a research project, for example, their order would be greater or more significant than if they had remained alphabetized on the shelf.

12. *Time* in physics can be highly troublesome, as relativity first showed. Though time as a first-order parameter has been thoroughly explored, it remains controversial, even to the extent that its reality is disputed or affirmed. (Smolin 2013, 2013a; Barbour 1999). Abstract time (like abstract space) is as much a human artifact as the clocks that measure it. It is worth exploring why modern physics seeks ultimate reality in such abstractions at all. Time is presumed as a background in both classical and quantum physics, even for situations in which time-keeping processes cannot be presumed to exist.

Toward 2nd-order Cosmology: the example of Lee Smolin

Much of Lee Smolin's work deals with processes of self-organization on a cosmic scale, which typically involve regulatory feedback mechanisms, such as autocatalytic cycling of energy and material in spiral galaxies. (Smolin 1997:130). He also questions current basal assumptions prevalent in the physics community, and often writes with unusual personal candor. There is much reason, therefore, to view his thought as going beyond typical 1st-order science. My intent here is not to evaluate his ideas, but to use their example to explore what a 2nd-order cosmology might look like and some obstacles to that vision.

Smolin's cosmic natural selection theory addresses what seems to be a simple question: why are the fundamental laws and parameters of nature such as they are?[8] But this question can be interpreted in two ways, according to whether one is inquiring about the *world* or about the human *process* of formulating laws and their parameters. The first regards what nature brings to our scientific portrait of it; the second, what the human enterprise of science brings. These approaches are complementary, representing the partnership of subject and object. The usual contribution of the scientist may include elements that (like observer interference) can be accommodated within a 1st-order

[8] The basic idea of the theory is that a new universe can emerge from the collapse of a black hole; it would then in turn contain black holes that could generate further universes. The kind of universe that would prevail would have parameters that maximize the number of black holes, on the model of Darwinian selection, explaining why we live in a "typical" universe.

framework. These might even include the design and execution of experiments, methods of data analysis, etc. However, there may also be the sort of unacknowledged contribution of theoretical assumptions and biases mentioned in the previous section, along with omission of certain kinds of question. For example, Smolin (1997: 26) raises this 1st-order question: “what must be true about the universe in order that it contain living things?” A complementary (2nd-order) question would be: what must be true about living things that shapes how humans do cosmology? While Smolin does not ask *this* question, he does often raise philosophical issues that cross a line between a 1st-order and 2nd-order approach.

Smolin (1997: 176; 2013: 123) proposes a universe that makes and tunes itself, challenging the notion of an externally configured world. A central fact for him is that there can be no observer outside the universe as a whole—contrary to the arrangement on which 1st-order science is normally predicated. He questions the usual assumption that universal regularities (such as the mass or charge of the election) must reflect “principle” rather than evolutionary history. He goes on to comment: “A model is just a game, meant to mimic some aspect of the world whose observed regularities can be posited in some simple rules.” (1997: 181) While this bears no explicit reference to an agent, clearly someone *plays* the game, someone *intends* for it to mimic the world, someone *posits* rules.

He wavers, however, when he raises philosophical issues involving the role of the subject or agent but does not follow through. In a sense, he is merely sticking to the point, to support his theory of cosmic natural selection. Yet, I cannot help thinking that the general cause of self-organization he champions would be furthered by elaborating the discussion he only broaches. Smolin rejects the tradition holding that “the world we see around us is… only a kind of movie constructed by our eyes” (1997: 196), yet stops short of conceding that physics is also a construction, an alternative “movie.” The aspect of an absolute perspective he rejects is limited to “timeless” (i.e., non-evolving) laws, for which he substitutes an absolute time in which laws evolve. While he notes the psychological motivation to escape time, the great tyrant, an unacknowledged greater tyrant is *contingency*, which broadly implicates cognitive strategies of the embodied creature to deal with its vulnerability.

Smolin proposes increasing order in the universe as a measure of time, inverting the 19th-century thermodynamic arrow of time. (2013: 249). A model of self-organization driven by gravity displaces the old model of diffusing heat. While this shift can be attributed to new knowledge, it’s worth dwelling (in hindsight) more generally on how new models based on new technology produce new metaphors that shape the current scientific vision. Lessons there should make us wary of the current obsession with computation and information as the basis of a new ontology of physics.

A 2nd-order approach would question the belief that reason can penetrate to an absolute reality. This could have led Smolin in a different direction than a metaphysically suspect resurgence of absolute time. He understandably opts for a theory he can defend as scientific. The theory rests on an analogy with Darwinian selection—relying on “small changes” from one generation to the next. Known causal mechanisms account for mutations in biology, but Smolin proposes no causal analogue to account for changes in fundamental parameters from one generation of universe to another; nor does he provide a rationale for why the changes would be small. He points out that this does not disqualify the theory from having falsifiable consequences, yet the metaphysical framework is as extravagant as it is in those other accounts involving multiple universes that he rejects.

For Smolin, laws are not eternal, but "constructed in time through physical processes." (1997: 188). The notion of eternal laws he rejects was thinkable in the context of the religious and classical heritages of science, but might never have arisen in a science embracing a metaphor of organism, instead of mechanism, in the first place. A view of matter as inherently self-organizing would not have fostered a science based on laws independent of matter and governing it somehow externally. The notion of laws "constructed in time through physical processes" has an odd ring, because it is *theorists* who construct laws, while nature simply changes—in recognizable patterns that may themselves be changing.

A similar example (Smolin 1997: 194) of such ambiguity concerns the nature of rationality and the rationality of nature: "there is good reason to hope… that a universe hospitable to our own existence… can be rationally comprehended without any need to refer to external agency or intelligence." Yet, one may ask, can it be comprehended without reference to *human* agency and intelligence—which remains "external" in 1st-order science? As Smolin suggests, nature should be comprehensible to us because we are part of it, not because we are made in the image of a rational god who is not part of it. Yet, precisely because we are embedded in it, are we not co-responsible for the very appearance of rationality that makes it seem comprehensible? Ours is the agency that posits eternal laws (and gods), for reasons that have as much to do with the needs of the human organism as with the rationality of nature. The very concept of rationality is a human category to examine in evolutionary terms.

Smolin (1997: 253) notes that when "we observe some part of the world, we become entangled with it in the same way that any two particles that interact become entangled, so that a complete description of ourselves is impossible without incorporating the other." However, assimilating epistemic entanglement to quantum entanglement is a way of managing a 2nd-order issue in 1st-order terms. To pass beyond the confines of those terms one must add: *and vice-versa!* A complete description of the world is impossible without incorporating ourselves as cognizing agents, not only as objects of cognition.

In another paper (1995: 31) he observes that, "with most choices of parameters a world would not have the complexity of ours." Discussion of alternative worlds is common coin in modern cosmology, as it was in the Middle Ages, to explain why the world is the way it is rather than some other way. Yet, one has to wonder whether multiplying worlds is too high a price to pay for explanatory leverage. Moreover, the issue is framed in 1st-order terms that avoid discussion of underlying assumptions. It is one thing for a programmer to choose which values of parameters to plug into computer models; it is quite another to assert that nature does this.

For Smolin, cosmic natural selection picks out which of many equally consistent possible worlds we actually find ourselves in. He sees that the hard problems of particle physics and of cosmology are intimately connected through the values of fundamental parameters, which involve "unnatural choices"—by which he means against all odds. While it is an interesting theory, for me there remains an unresolved basic issue concerning the ambiguous notion of "choice." Is it nature or the theorist who chooses?

Keeping the theory at the 1st-order level masks this question. Causality in the world is not distinguished from the theorist's intentionality. Moreover, if something is actually the case, then in what sense is it "unnatural"? It strikes me as more unnatural to posit a multiplicity of universes and an absolute time to contain them.

The same paper (Smolin 1995: 43) argues that both relativity and quantum theory require a world of a certain complexity. The argument develops an idea of Leibniz, that complexity depends on the unique identity of locations, which can be distinguished by what is visible from them. Smolin attempts to quantify a notion of variety based on this scheme. The interesting thing for this discussion is that, as with Leibniz' monads, points of space-time in his treatment can be thought of *either as particles or as observers*. The question, of whether and how to dissolve the distinction between subject and object, requires a place for such speculation in the realm of 2nd-order science.

Future directions

The foregoing discussion suggests several possibilities for future research:

1. Cosmologists could embrace the working assumption that the material world has unrecognized mechanisms of self-organization. They could look for analogies in biological science: e.g., the role in reproduction of "junk" DNA and environment, as opposed to genome, or the role of glial cells in the brain. The notions of cybernetic system and autopoiesis could tentatively be applied to galaxy formation, nucleosynthesis, the role of gravitation and entropy in early history of the universe, etc.

2. Physical scientists could extend the notion of observer influence to include conceptual as well as physical influences. They could look to cognitive theory, evolutionary psychology, and evolutionary epistemology for inspiration. An abstract notion of "cognitive possibility" could provide guidance, on the model of mathematical possibility (where equations allow "unphysical" solutions): how might an alien physicist approach the problem?

3. At observational limits, both cosmology and quantum theory deal with weak signals, statistical interpretation, and long chains of inference—ideal ground for "observer influence." Scientists in these fields could look to stages of cognitive processing for suggestive analogies.

4. Scientists in general could inquire how standard practices of idealization and mathematical modeling constrain both theory and observation. They could profitably question the meaning of observation and measurement in their fields, the participatory role of the theorist or experimentalist, and other basic assumptions taken for granted.

Conclusion

The merger of high energy physics with modern cosmology points to limits of a 1st-order approach based on an external observer. Though physical science traditionally clung to description of the object, the domain of discussion can now productively expand to include the subject's role in the co-creation, with nature, of the scientific narrative. Acknowledging the partnership between subject and object enhances the objectivity of an account, with the traditional benefits of prediction and control. Subjectivity is a defining fact of human life and consciousness; far from posing a threat, it is an essential glue of society and the real basis of whatever objectivity is humanly possible. In cosmology in particular, expanding the domain of discussion might open the door to a broader treatment of agency in the non-living world, shedding new light on self-organization.

I do not believe that a final theory will "bring to an end… the ancient search for those principles that cannot be explained in terms of deeper principles." (Weinberg 1992: 18). Nor is an ideal of theoretical completeness feasible that requires a one-to-one mapping between theory and natural reality. (Einstein et. al. 1935). Rather, a *complete* theory would be one that includes the role of the scientist in creating theories and experiments. Such reflexivity would of itself forever eliminate the possibility of a *final* theory. On the other hand, if fundamental physics does reach finality through some consensus, its subsequent natural direction would be toward self-reflection, perhaps relaxing requirements such as quantification, prediction, and the exclusion of "secondary" qualities. Such a science might be better positioned to understand the relation of "mind" to "body."

We have examined some of the subtleties involved in what might constitute a second-order cosmology, using the example of Lee Smolin's theory of cosmic natural selection. Professor Smolin asks: "If not for the philosophers, who is going to have the courage to tell the physicists when quantum theory, or another of our constructions, just cannot be made sense of?" (1997: 195) Undoubtedly *he* has this courage. Yet our answer should be that such soul searching ought to be more widely incorporated into physical science itself. The objectivity that is the ideal of first-order science ultimately means adequacy in the evolutionary landscape. In that respect, for human civilization and current science in particular, the jury is mercifully still out.

REFERENCES

Barbour J. (1999) The end of time: the next revolution in physics. Oxford UP, New York

Baum E. (2007) A working hypothesis for general intelligence. Proc. of the 2007 conference on advances in artificial general intelligence.

Bruiger D. (2006) Second nature: the man-made world of idealism, technology and power. Trafford/Left Field Press, Victoria, BC

Cartwright N. (1999) The dappled world: a study of the boundaries of science. Cambridge UP, Cambridge, MA

Foerster H. von (1979) Cybernetics of cybernetics. [https://www.academia.edu/5994177/Cybernetics_of_Cybernetics]

Hartle J.B. (2010) The quasiclassical realms of this quantum universe. [http://arxiv.org/pdf/0806.3776.pdf]

Heylighen F. (2001) Cybernetics and second-order cybernetics. In: Meyers R.A. (ed.) Encyclopedia of physical science & technology (3rd ed.), Academic Press, New York,

Heylighen F. (2014) Principia cybernetica web: web dictionary of cybernetics and systems. [http://pespmc1.vub.ac.be/ASC/INdexASC.html]

Holton G. (1988) Thematic origins of scientific thought: Kepler to Einstein. Harvard UP, Cambridge, MA/London

Kenny V. (2009) There's nothing like the real thing': revisiting the need for a third-order cybernetics. Constructivist Foundations. 4(2) [http://www.univie.ac.at/constructivism/journal]

Mets A. (2012) Measurement theory, nomological machine and measurement uncertainties (in classical physics). Studia Philosophica Estonia 5(2)

Penrose R. (1989) The emperor's new mind: concerning computers, minds, and the laws of physics. Oxford UP/Penguin, New York

Schiefsky M. (2012) The creation of second-order knowledge in ancient Greek science as a process in the globalization of knowledge. In: Renn J. (ed.) The globalization of knowledge in history, Open Access Edition

Smolin L. (1995) Cosmology as a problem in critical phenomena. [http://arxiv.org/pdf/gr-qc/9505022.pdf]

Smolin L. (1997) The life of the cosmos. Oxford UP, Oxford/New York

Smolin L. (2013a) Temporal Naturalism. [http://arxiv.org/pdf/1310.8539.pdf]

Smolin L. (2013) Time reborn: from the crisis in physics to the future of the universe. Houghton Mifflin Harcourt, Boston/New York

Tegmark M. (2007) The mathematical universe. [http://arxiv.org/pdf/0704.0646v2.pdf]

Umpleby S. (2011) Second-order science: logic, strategies, methods. (power point presentation) [www.gwu.edu/~umpleby/recent_papers/2011/wmsci_sos3.ppt]

Weinberg S. (1992) Dreams of a final theory. Pantheon books, New York