

The Theological and Metaphysical Import of Contemporary Cosmology

Wesley J. Wildman, Boston University, September 2, 2006

Introduction

Physical cosmology is a discipline within the physical sciences that famously provokes many boundary questions with metaphysical and theological significance. Some of these questions are debated in the community of scientists studying physical cosmology when they need to clarify their procedures and whether what they are doing still counts as science. As complex as methodological questions in physical cosmology can be, these self-policing activities among scientists are just the tip of the iceberg of philosophical debate. Because physical cosmology concerns all of physical reality, at least in some aspects, its discoveries and theories and problems possess significance for the parts of philosophy and theology that ponder nature as a whole. For the sake of convenience, I shall follow Alfred North Whitehead and call these broader ventures “philosophical cosmology,” collecting both philosophy of nature, ontology of nature, theology of nature, and the cosmological parts of natural theology into the semantic net.

The inferential journey from physical cosmology to philosophical cosmology is complicated—far more complicated than is sometimes supposed by eager physicists and theologians. A classic example of underestimating the complexities involved was the enthusiasm surrounding the observational confirmation of big-bang cosmology. In 1951, Pope Pius XII issued an allocution claiming that the big-bang confirmed the Catholic Church’s teaching about the divine creation of the universe. Years later, in a 1978 article for the *New York Times*, astronomer Robert Jastrow wrote that scientists through their arduous labors had accidentally confirmed what religious folk had naively believed all along, namely, that God created the world from nothing. Both forms of enthusiasm (delighted or frustrated, as the case may be) were premature. Physical cosmologists have rung a host of changes on their theories in the last three decades and discerning the implications for philosophical cosmology is becoming an increasingly difficult task.

Some philosophers and theologians eschew the inferential journey from physical to philosophical cosmology altogether. They try to frame their philosophical theories of ultimate reality in such a way that they will be consistent with any conceivable discovery of the physical sciences, and thereby invulnerable to falsification by the rapidly changing trends of cosmology. A classic example of this is American theologian Langdon Gilkey, who built his theological interpretation of creation not on any scientific understandings of the origins of the universe but on the existentially potent fact that human beings are profoundly dependent on the universe for life and purpose. This is an understandable strategy, especially in the context of a theology that is intended to bring security to religious believers by giving them a stable understanding of their faith, as Gilkey’s was, in part. Outside this faith-supporting context, however, philosophical cosmologies need have less concern about throwing their lot in with the rapidly changing fortunes of physical cosmology, and attempting to strike a balance between stable theoretical formulations and sensitivity to the changing scientific details.

I am proposing here imaginatively to construct a transitory patch of stable theoretical territory within the dynamic world of contemporary physical cosmology research, there to evaluate its metaphysical and theological import. Little of lasting value for philosophical cosmology can be accomplished through this venture. Like stock-taking in a supermarket, things change before you finish counting. But there may still be value in a snapshot of the implications for philosophical cosmology of physical cosmology’s recent ideas. Another limitation of the proposed plan is that I do

not have a mathematical understanding of contemporary cosmology beyond basic general relativity and big-bang cosmology, despite my training in physics and mathematics. This limits my appreciation for the all-important details of more recent cosmological theories, from inflationary cosmology onwards, and I must rely on semi-popular accounts of them. From what I hear, however, almost no physicists understand the mathematics of string theory, not even some of the most famous physical cosmologists, so there is no need to panic. These days, physical cosmologists are inhabiting such diverse theoretical worlds that they have to translate their theories at a semi-popular level even for each other.

What can we expect from physical cosmology in terms of constraints on the various competing philosophical cosmologies floating around in the minds of philosophers? Contrary to the claims of traditional natural theology, I think that direct inference from facts about the world to knowledge of ultimate reality is a vain ideal.¹ Rather, the variety of philosophical cosmologies are vast conceptual hypotheses that can be tested against current understandings of the natural world. Physical cosmology can impact the plausibility of such philosophical hypotheses both positively and negatively. But any philosophical cosmology can hold out against plausibility-reducing considerations if it possesses enough other virtues by weighting the criteria for plausibility in such a way that its virtues count more than its deficits. That is to say, these hypothetical philosophical cosmologies are so rich that they can sustain within their supporting traditions their own plausibility structures, which are consistent with but also to some degree independent of universal rational considerations such as coherence, consistency, applicability, and adequacy.

This makes debates between competing philosophical cosmologies difficult to construct and manage. But it also correctly recognizes precisely how complex is the process of theory-construction in philosophical cosmology. Evidently, physical cosmology may be able to put pressure on philosophical cosmologies—some more than others—but it cannot reasonably expect to rule out all but one decisive victor. There is nothing new in this picture of human rationality. We know that rational discourse is borne on traditions of debate, that people routinely disagree on the plausibility structures appropriate for evaluating competing theories, and that it is easier to identify inconsistency within the nearly incorrigible worlds of philosophical cosmology than it is to show that one world is rationally superior to another. This is the philosophical correlate to the theological problem of religious pluralism.

Philosophical Cosmologies

For the sake of concreteness, I shall keep an eye on three philosophical cosmologies as we move through the various considerations from physical cosmology to be discussed below. Each is a class of views, in fact, and there are intriguing fights internal to each class about the advantages and disadvantages of the various formulations. They are significantly different as classes of views, however, and views within each class react similarly to the theories of physical cosmology, so it makes sense to treat each class as one general view.

One view is a supernatural cosmology, in which the world of nature is open to influence and control by beings beyond the natural world. On this view, typically there are Gods or a God, as well as discarnate entities, with determinate features such as intentions and plans, feelings and responses, and powers to act in the world. This means that the natural world may have its causal rules but that they are not absolute; the normal flow of causal connectedness can be interrupted at any time for reasons having nothing to do with antecedent conditions in nature. The interruptions may be

¹ I argue this in detail in Wesley J. Wildman, “Comparative Natural Theology,” *American Journal of Theology and Philosophy* 27/2&3 (May/September, 2006): 173-90.

miraculous, in the sense of abrogating natural laws, or they may be somehow consistent with natural laws by working in causal gaps within nature, if such gaps exist, but they express supernatural intentions in either case. In the theistic version of this supernatural cosmology, there is one omnipotent deity who is the ultimate reality, who creates everything, who has determinate features, and who interacts with the world according to divine purposes. The natural world may or may not reflect the deity's determinate character, just as the potter's clay may be forged into shapes that both express and fail to express the potter's personality. But the deity is nonetheless responsible for the created world in some ultimate sense. This gives supernatural theism considerable flexibility of interpretation in relation to the metaphysical implications of physical cosmology. The laws of nature and fundamental features of the physical cosmos are created, yes, but they may or may not reflect God's character. We will see that this flexibility of interpretation is the key to why supernatural theism is relatively independent of considerations from physical cosmology.

A second view is process cosmology, which is a form of naturalism. All naturalistic cosmologies explicitly deny the reality of supernatural entities, and process cosmology is no exception; the causal web of the world is unbroken because there is nothing to break it. The God of process cosmology is a natural entity within the world that plays a special role in every causal interaction. This God is not omnipotent, does not create the universe from nothing, and is not the ultimate reality. But the process God does have a determinate character, in the sense that its primordial nature is an envisagement of possibilities and values that is constantly presented to the moments of reality, and its consequent nature is a value-maximized version of the world's actuality. The natural world is in an eternal symbiotic relationship with this natural God, such that the two mutually influence and constitute one another. This implies that there must be a close connection between the discoveries and theories of physical cosmology and the nature of the process deity. The fundamental causal structure of nature is not established by God, of course, but values and abstract concepts are rooted in this God's nature, and from there conveyed to the world, giving it regularity and meaning. The fundamental regularities and constants of nature, its beauty and mathematizability, and the value and meaning that it sustains, all participate in and reflect the divine nature. In this way, within the process framework, physical cosmology can expect to find out about God indirectly as it ventures to form an understanding of nature as a whole.

Finally, we shall also attend to another naturalistic cosmology. I do not refer to the sensationalist, atheistic, materialist form of naturalistic cosmology that David Ray Griffin and others have so comprehensively criticized; indeed, I take the demonstration of the conceptual and empirical inadequacy of this flattened-out atheistic cosmology to be one of the great achievements of contemporary philosophy of religion. Rather, I refer to forms of religious naturalism that posit God as the ground of nature's being, as its depth structures. This shares with process cosmology the rejection of supernatural entities but it goes further to reject the idea of God as an entity of any sort, even a natural entity as in process cosmology. From the supernaturalist point of view this amounts to atheism, in respect of denying that there is an existent divine being, or to pantheism, in respect of denying a sharp ontological distinction between God and the world. But identifying God with what German-American philosopher of religion Paul Tillich called the depth dimension of reality does preserve the transcendence of God while also affirming God's immanence in the world process. Moreover, because this God is ultimate reality, unlike the God of process cosmology, all of nature is ultimately sacred in its depths. I suspect that most scientists who refuse to identify with theism do so because they think of theism in supernaturalist terms. Yet many of them hold spiritual worldviews akin to the ground-of-being cosmology; they just don't think of their worldview as theistic (and non-theistic versions of the ground-of-being cosmology do exist). The scientific exploration of nature is a kind of theological expedition, on this view, just as the literature of nature mystics and the poetry of nature lovers is essentially theological. Ground-of-being cosmology virtually identifies the character

of nature as envisaged in its mathematical and causal deep structures with the divine nature, if it receives a theistic formulation. Indeed, this cosmological framing of the God idea within a religiously potent form of naturalism radically collapses traditional distinctions between sacred and secular, general and special revelation, nature and grace, suffering and bliss, western theism and eastern non-theism.

These three classes of philosophical cosmologies—I am calling them supernatural cosmology, process cosmology, and ground-of-being cosmology—respond quite differently to the discoveries and theoretical models of physical cosmology, as suggested above. Supernaturalistic cosmology has the most flexibility because of the logical space between the character of the natural world and the character of God as its creator, and thus can remain relatively independent of physical cosmology. Ground-of-being cosmology has the least flexibility in its responses to physical cosmology because God just is the mathematical, relational, causal structures of nature, in part; we encounter ultimate reality in the depths of nature that science uncovers. Process cosmology is somewhere in between; physical cosmology can disclose value structures that reflect the primordial nature of God but the fundamental causal structures of the universe, and the ultimate reason it is the way it is, are questions that process cosmology cannot answer, because it is a cosmology without an account of ultimate reality.

It is important to remember that each of these three classes of cosmologies is internally diverse. For example, the supernaturalistic cosmology includes the theistic cosmology of intelligent design, the theistic cosmology of theistic evolution, the theistic cosmology of Enlightenment deism, the Trinitarian cosmology of Christian Neo-Platonism, the morally dualistic cosmologies of Zoroastrianism and Manichaeism, the ontologically dualistic cosmology of Cartesian theism, and the polytheistic cosmologies of the ancient world, which persist in quieter forms even today in nature religions and tribal religions. Yet these diverse views display similar patterns of logical response to physical cosmology. With that in mind, we turn to a series of issues in contemporary physical cosmology, looking to see how they constrain the three philosophical cosmologies I have presented. I shall take the meaning within physical cosmology of each of these issues almost for granted, limiting exposition of the physics to brief summaries, in order to focus on their significance for philosophical cosmology.

Fine Tuning

“Fine tuning” refers to the discovery that many fundamental constants and boundary conditions of nature, most apparently independent of one another, have to be quite precisely what they are (with only tiny variations) if life as we know it or can imagine it is to be possible. This profoundly arouses the scientist’s curiosity. The physicist’s automatic reaction to such a puzzle is inspired by the repeated success of reductionism in physical modeling: these numerous independent fundamental constants must be connected manifestations of a deeper principle or process that somehow sets them all at once. But even that does not explain why the constants are set so as to permit stars, planetary systems, chemistry, and life.

The supernatural cosmology stands ready with a bluntly anthropomorphic explanation for fine-tuning, of course, which is known as the design argument. A divine being wanted the world to have life and complexity and spirituality, so a designer’s intention lies behind fine tuning. Meanwhile, proponents of the ground-of-being cosmology would be happier if the contingent elements of fine-tuning were eliminated, or at least reduced through being connected to one another in a necessary account of the cosmos, whether a multiverse or a universe. For their own theological reasons, having especially to do with theodicy, they do not want the universe to display evidence of divine design. Process cosmology has an extremely complex relationship to fine tuning, and I will return to that presently.

Physicists hotly debate whether anthropic reasoning has a role in making sense of fine tuning.² But their concerns are frequently different than those of philosophers and theologians. For example, for physicists the question is not whether fine tuning entails a divine designer, but rather what the logical force of anthropic reasoning can be. At one level, fine-tuning merely describes the way the world is—namely, good for *anthropoi*—and at that level the anthropic principle merely repeats the description without explaining anything. Likewise, in multiverse scenarios that propose an array of universes with different settings for fundamental constants, the anthropic principle merely locates us within a small class of those possible or actual universes, and so once again explains nothing. Yet, at another level, anthropic reasoning sometimes does more work for physicists than merely redescribe the universe we inhabit. For instance, string theorists proposing a superstring landscape with 10^{500} vacuum states, each corresponding to a possible universe with unique settings for fundamental constants, can use the fact that we live in an anthropically hospitable universe as a constraint on their speculative mathematical theories.³

Few physicists are willing any more to interpret fine-tuning as evidence of intentional divine design. There are just too many possibilities for multiverses, whether as Neil Turok and Paul Steinhardt's cyclical-universe scenario with changing fundamental constants on each bounce, as Andrei Linde and Andrei Sakharov's eternal inflationary multiverse with different fundamental constants in each inflationary bubble, or as Leonard Susskind's superstring landscape theory, to name the some of the most prominent contenders. If the settings of fundamental constants really can differ among "verses" of a multiverse, then fine tuning presents no anthropic mystery whatsoever, and offers no positive evidence for the supernatural philosophical cosmology. In that case, philosophical cosmology has to resort to the basic metaphysical questions of "why is there something rather than nothing?" and "why is the something organized the way it is?" Then philosophers are back in Gilkey's territory, with the salience of fine tuning reduced roughly to the existentially basic issue of human dependence on a cosmic environment, which can be elaborated in a philosophical cosmology without having to worry too much about the detailed organization of the cosmos we know.

The process cosmology can go either way with fine tuning but it has to tread carefully. On the one hand, the process cosmology can live with the scenario that suits the supernatural cosmology. Process cosmology cannot explain the universe's fine-tuned particularly as a result of divine intention in the way that the supernatural cosmology can, of course, because the process God is not an omnipotent creator. But process cosmology can propose that God influences the very early phases of expansion within a preexisting universe (by the usual means within the process account of prehensive causation) in such a way that the universe takes on anthropically favorable fundamental constants. The problem with this, obviously, is that it proposes an explanation outside physics for the setting of the fundamental constants of physics; moreover, it is a mechanism that contradicts current assumptions within physics about fundamental constants being already set in the very earliest moments of the big bang and not a matter of development that can be susceptible to causal influence.

On the other hand, process cosmology can also live with the necessary universe scenarios that suit the ground-of-being cosmology, but again at a price. If the apparently independent constants and boundary conditions one day turn out to be theoretically and ontologically necessary

² See, for example, Tom Siegfried, "A 'Landscape' Too Far?" in *Science* 313 (Aug 11 2006): 750-54, which reports on a Newport Beach Conference at which the meaning and advisability of anthropic reasoning took center stage.

³ {Do I have this correct??}

and not contingent, then that just defines the universe within which the process God operates; no problem there. But if the independent constants and boundary conditions are relativized in a multiverse scenario, then the philosophical cosmology of process metaphysics has a serious problem. If one God is active in all epochs of the universe, as Whitehead proposed, rather than one process God for each epoch, then God has an extra responsibility to keep prehensible information in one universe separated from prehensible information in every other. This may not be consistent with Whitehead's theory of prehension, which may need to be adjusted accordingly. The result, I fear, would be slightly *ad hoc* and less attractive than process cosmology's current theory of causation.

Whereas the supernatural cosmology looks for contingency as evidence of the design it presumes, and the ground-of-being cosmology seeks necessity to avoid the suggestion of intentionality in the depths of the universe, the process cosmology searches for consistency of fit between what we know of physical processes and its own account of causal processes. This may force the process cosmology to adapt to changing knowledge in the physical sciences but the process cosmology appears to be flexible enough to accommodate necessary adaptations when they are needed.⁴

Arrow of Time

The "arrow of time" refers to our experience that time flows in one direction, like traffic on a one-way street. This is most strongly attested in physics within thermodynamics, where entropy increases with time in a closed system. Paradoxically, however, virtually all of the basic equations of physics are symmetric in time (i.e. they work as well going forwards in time as they do going backwards in time) and so the emergence of a thermodynamic arrow of time from fundamental physics remains deeply puzzling.

The physicist's natural instinct here is to look for some process of symmetry breaking, wherein the early universe commits to a unique direction of time as its energy density decreases in the early part of the big bang. This would not be at all surprising, in principle, as there are several such symmetry breakings in the early universe, and scientists have good mathematical models and solid experimental evidence for some of them. But this particular symmetry breaking would have to occur very early, in the quantum-gravity era that links space-time with the physics of particles and forces that quantum mechanics handles so well. Because the energies for experimentally testing theories of quantum gravity lie far outside achievable levels for the foreseeable future, any proposals for symmetry-breaking explanations for the emergence of the arrow of time must remain wholly speculative, much as string theory currently is.

Another approach within physics to the arrow-of-time problem is to note that existing physics does not support the ideas of a laminar or a unidirectional flow of time. The quantum theory of the vacuum state suggests that there must be whirls, loops, and weird geometric chaos in space-time, which means that time at the smallest level is anything but a laminar flow. And quantum electrodynamics, one of the experimentally most robust theories of modern physics, routinely supposes that virtual particles can move backwards as well as forwards in time. This suggests that

⁴ A nice example of the adaptability of process cosmology is David Ray Griffin's solution to a problem that appears in Charles Hartshorne's version of process cosmology. Hartshorne proposed that God was a society of occasions, so as to solve a problem of responsiveness that he detected in Whitehead's cosmology. But this entails the stipulation of a universal present, of which special relativity can make no sense. Though this deeply troubled Hartshorne, Griffin correctly pointed out that a universal present does not contradict special relativity, to Hartshorne's relief. This problem has another version pertaining to the quantum vacuum, with its non-laminar account of space-time, as discussed in the section on the arrow of time.

symmetry breaking cannot explain every aspect of the macroscopic arrow of time but only the average direction of the flow of time, much as free electrons in a current-carrying wire bounce all over the place but move on average in particular direction.

The implications of all this for philosophical cosmology are intriguing. The supernatural cosmology ascribes intentions to God, which are necessarily temporal things, so there is an inherently temporal aspect to the divine nature, much as there is in the cosmic arrow of time—and this despite traditional affirmations of the eternity of God, according to which divine intentions seem oxymoronic. The temporality of the divine life also reflects the narrative structure of religious accounts of God's saving activity in the world, in which there are problems for God to solve and actions that must be taken depending on what human beings do. Such salvation-history narratives only make sense if God's temporal nature and the world's arrow of time are commensurable. But a supernatural cosmology can achieve this through positing supernatural souls for human beings (and appropriately modified souls for animals and plants), which can be geared in to the temporal life of God even if fundamental physics is not. Thus, the supernatural cosmology has all the resources it needs to confine the arrow-of-time problem to the recondite domain of physics, thereby sidestepping any constraints it might impose on philosophical cosmology.

The ground-of-being cosmology is, as always, deeply tied to physical cosmology, and so the character of space-time as physics gradually reveals it reflects and just is the deep-structure of reality. One conclusion that might be drawn from this is that there is something illusory about the human experience of time's arrow. Of course, this is said often enough by people experiencing different rates of time's passing, depending on their state of mind. But the illusion may be far more dramatic than this; indeed, the quantum account of the vacuum and the absence of an arrow of time in the fundamental equations of physics may be evidence of it. Some ground-of-being cosmologies (typically non-theistic formulations within South Asian or East Asian philosophical frameworks) make a great virtue of the illusory character of human experience. In such pictures of reality-as-a-whole, the ultimate path for human beings is one that eventually enlightens us and allows us to see reality as it is, through the shrouds of perception and cognition. Such viewpoints naturally expect every aspect of human experience, including the arrow of time, to be deeply misleading in some way or another, and contemporary physics (as well as cognitive science) just serves to confirm what adepts can discover differently through meditation and disciplined reflection on perception.

Process cosmology is more closely tied to the character of the physical cosmos than the supernatural cosmology is, and so process thought has to grapple explicitly with the problem of the arrow of time. Indeed, process cosmology has an extraordinarily rich account of causation that purports to explain the experience of time in complex organisms, such as human beings. But the prehensive account of causation leads to a strongly one-way flow of time, albeit a fundamentally atomized, foaming flow, which faces technical difficulties in light of the quantum account of the vacuum. Moreover, despite its unusually detailed account of the emergence of an arrow of time, process cosmology seems unable to show how its philosophical account of causation should impact the quest in physics for a satisfying account of the emergence of an arrow of time. There is no reason to think that process cosmology lacks the wherewithal to solve the first of these challenges, though it will not be easy, and the solution may require modifications to the standard process accounts of prehension.

Chance and Law

Physical cosmology, like the physical sciences as a whole, intriguingly portrays nature as a fecund interplay of chance-like and law-like events. There are many unsettled details about the large-scale geometro-dynamics of the universe, but physical cosmologists agree that the process of cosmic expansion is constrained in law-like fashion. The equations of general relativity, or some variation of

them, offer what seems to be an accurate large-scale picture of the relation between space-time and the energy and massive objects in the universe. The corresponding behaviors of natural objects seem law-like because we have this mathematical account of them, and this remains so whether we say that the mathematical laws reflect ontological laws of nature or that they merely describe natural regularities. Yet nothing about general relativity allows us to predict the detailed distribution of matter from the conditions of the big-bang. We might know average energy density at a particular time and we might be able to calculate the probability of having a galaxy cluster in a particular region of space but the details of the big bang play out in chance-like ways, constrained by law-like regularities in nature.

Variations in temperature of the cosmic background radiation reflect the chance-like process by which the early universe became transparent to light, happening faster where mass-energy density was lower, and slower where densities were higher (which is also where vast galaxy walls would eventually form). Yet the overall process of cosmic expansion determines in law-like fashion what the average temperature of the background radiation will be and how large is the variance in temperature differences. Similarly, in the superstring landscape, a statistical law governs what sorts of universe can spring from any existing universe, with the overall family tree of universes migrating down a vast energy potential. But the particular fundamental constants and initial conditions of an existing universe do not completely determine those of a child universe; that is a chance-like process constrained by that law-like statistical migration through the energy potential of the multiverse's entire landscape of vacuum energy states.

The story of fecund interplay between chance-like and law-like process can be repeated for almost all of the observed features of the physical cosmos. This is an extraordinarily rich theme for philosophical cosmologies because it links the large-scale law-like constraints on cosmic development to the intimate details of particular places, times, and events, with their special qualities and meanings. It also opens up the problem of suffering in nature, which is one of the consequences of chance-like events within the canalizing constraints of law-like processes, whether it be collisions within merging galaxies or asteroid collisions within solar systems that wipe out entire ecosystems. Predictably, the three classes of cosmology under discussion have different reactions to this solar system.

The supernatural cosmology in one classically theistic form is committed to divine design of the cosmos, to God's ultimate omnipotent control over the entire process, and to the overall maximal goodness of the particular arrangement that physical cosmology describes for us. We are in the best of all possible worlds, on this view, because an omnipotent and omnibenevolent God would not have made things in any other way. Thus, chance-like events subserve the providential plans of God even as law-like processes do. The price for complex life capable of genuine moral freedom and fellowship with the deity is chance-like events that often enough cause suffering. But the vale of tears and joy that is this world is but a foretaste of a supernatural world of blessed experience to come, so nothing that happens here seriously dents the picture of God's goodness. Other forms of the supernatural cosmology are more realistic about the problem of pain and suffering and posit two equipotent deities with opposite moral valence who battle for control of the cosmos, which explains why both good and bad things happen, why they cannot be prevented, and why neither can ultimately dominate the other. The shared strategy here is to frame the philosophical cosmology in such a way that the painful downside of the interplay of law-like and chance-like processes does not reflect on the overall goodness of the creator deity (or the good deity we choose to follow—this is much the same as in process cosmology).

Proponents of the ground-of-being cosmology are deeply frustrated with the supernatural cosmology's convenient distancing of God's moral character from the morally ambiguous interplay of chance-like and law-like processes uncovered by the modern natural sciences, including physical

cosmology. The “it’s all worth it” and “it will all be OK in the end” strategy strikes them as an *ad hoc*, artificially face-saving adjustment of viewpoint that was actually much more plausible prior to contemporary cosmology, when God created the world required for providential ends without worrying about billions of years of windup in the form of cosmic and biological evolution. If God’s purposes were what the salvation narratives of supernatural theisms say, then God would have created in the way Genesis described, or the way C.S. Lewis pictures it in the *Chronicles of Narnia*, with Aslan singing creatures out of the ground and into existence. The story of cosmic evolution severely strains the supernatural cosmology and naturally suggests a very different kind of ultimate reality, which is one of the main motivations for the ground-of-being cosmology. The deity in any theistic formulation of a ground-of-being cosmology would have to be morally ambiguous, the fecund source of both order and chaos, both weal and woe, because such a God would be the deep structure of the world as we encounter it.

The process cosmology is ideally suited to managing the contemporary scientific picture of nature as a fecund interplay of chance-like and law-like events—in fact, on the process account of causation, there really are chances and there are also laws that reflect the primordial nature of God, so we can drop the “-like” caveat. Process cosmology evades all of the traditional theodicy difficulties by refusing to furnish an account of ultimate reality. This cosmology limits itself to describing how God operates within the rules of the cosmos, which include this fecund interplay of chance and law. Whitehead gives a beautiful account of the interplay in *The Function of Reason*, and he remained perfectly comfortable not providing the account of ultimate reality that defenders of supernatural and ground-of-being cosmologies insist is necessary to complete any adequate philosophical cosmology.

Intelligibility and Observability

The fact that the physical cosmos is subject to observation, description, and mathematical analysis is truly staggering. To the one who understands what is meant, the deceptively simple equation $G_{\mu\nu} = 8\pi T_{\mu\nu}$ is a blessed icon of the miracle of cosmic intelligibility. This is the same wondrous miracle that drove Pythagoras to found a secret community to investigate the mysteries of mathematical demonstrations (and nude wrestling). It is the same marvel that inspired Plato’s elevation of the realm of mathematical intelligibility above all other aspects of reality, and Whitehead’s positing of a primordial nature of God to house the conceptual world that our mathematics enables us to explore. From the point of view of how surprising it is, cosmic intelligibility seems to be a bizarre fact of life pregnant with meaning.

Einstein worked for ten years to come up with a way of picturing both the distribution of stress-energy and the curvature of space-time that would permit him to describe mathematically the way they influence one another in the equation $G_{\mu\nu} = 8\pi T_{\mu\nu}$. He followed the lead of his astonishing intuitions and eventually reaped the harvest of his prodigious effort. But he then used it to produce unprecedented accuracy in the estimate of the precession of Mercury’s perihelion, and to predict that a specific amount of gravitational lensing of light should be visible around the edges of the sun during an eclipse. And that is other half of the miracle: we can make observations about the cosmos that help us decide which theoretical vision of its law-like processes is more accurate. Newton predicted that light would not bend; there should be no lensing. Einstein said light would bend; there would be lensing. People went out on a ship, rugged up to stay warm, in search of a place where they could see a solar eclipse, and when they got there, they saw lensing. Newton was wrong and Einstein was right. Moreover, Einstein predicted the right amount of lensing. Staggering.

This double miracle, so sacred within physical cosmology, is deeply exciting to philosophical cosmologists. They rush in with gloriously satisfying explanations of how it is that the logos of

human minds and the logos of cosmic processes harmonize, with mathematics as their shared language, simultaneously describing the beautiful cosmos while expressing our mind's beautiful take on the universe we inhabit. But these explanations are quite different depending on the ontological framework of the philosophical cosmology.

The supernatural cosmology offers the vision of a world made by God specifically to reflect the divine intention that it should be intelligible, and human beings gifted by God specifically to be able to encounter cosmic order through observation and mathematical analysis; the miracle of intelligibility is God's gift to us. The ground-of-being cosmology paints a picture of a species evolutionarily adapted to survive in the world, a side-effect of which is its ability to satisfy its curiosity through systematic inquiry in which speculative explanations are honed through testing and observation; the miracle is our evolutionary birthright. The process cosmology portrays every part of the world—including cosmic objects and the civilizations that study them—as participating in value structures native to the divine mind; the miracle confirms the process deity's causal presence in the structuring of all value and intelligibility.

Conclusion

There are many other aspects of physical cosmology whose import for philosophical cosmology could be investigated. Enough has been said, however, to see patterns in the distinctive ways that our three classes of philosophical cosmology react to the discoveries and theories of physical cosmology.

Supernatural cosmology maintains significant ontological space between the ontological character of ultimate reality and the character of the physical cosmos as science discloses it. This allows it to preserve its narratives of supernatural providence, without having to worry too much about constraints on its narratives flowing from physical cosmology. There can be large-scale plausibility problems with this view but the plausibility conditions necessary for maintaining it are effectively nurtured within religious groups for whom the supernatural cosmology offers more hope and meaning than any competitor worldview. The plausibility problems only hit home when active plausibility structures weaken to the point that the worldview becomes vulnerable, as it has done in secularized parts of western civilization. Meanwhile, in the mainstream of religious belief and practice, the supernatural cosmology continues to be the dominant way that human beings extrapolate from their everyday experience of the world, including as disclosed by physical cosmology, to a philosophical picture of the world as a whole that helps them manage their lives.

The ground-of-being cosmology is an ancient view that has always and in all traditions persisted on the underside of supernatural cosmologies, establishing a symbiotic relationship with them. Ground-of-being views do not appeal spiritually or emotionally to most people but the minority who break away from supernaturalism, if they are lucky enough to find out about ground-of-being cosmology, can warmly embrace this form of naturalism and its account of ultimate reality. It closes down the convenient space that the supernatural cosmology maintains between God and the world, so that theologians must grapple with the ultimate significance of the deep structure of nature as we encounter it through the sciences. This sanctifies the findings of science, and answers Stephen Hawking's famous question about who puts the fire into the equations of physical cosmology. There is no who, in the sense of a personal deity whose creation expresses a deliberate plan, but there is a Heraclitian fire in the belly of reality that unfolds in morally ambiguous fashion through the process of cosmic and biological evolution and yields our own species as the kind of fruit that enjoys permission to glimpse it, to celebrate it, and to engage it through inquiry and through creativity.

The process cosmology turns a corner in the history of philosophical cosmology and eschews an account of ultimate reality. In its place, it offers a picture of causality that ties the process

cosmology more closely than the alternatives to the details of physical cosmology. This produces both awkward technical conflicts and also the joy of overcoming them. It also offers a morally intelligible portrayal of a God whose limited but pervasive role is to maximize value in the cosmos through urging it forwards in every moment and at every level of complexity.

Is there enough here to see how physical cosmology might function as a test for these three classes of philosophical cosmologies? And does this test separate them, preferring one worldview over the others in any respects? I think that tentative conclusions of this sort are possible.

- In respect of the virtue of concrete intelligibility brought by the possibility that the findings of physical cosmology might falsify a philosophical cosmology, process cosmology clearly comes out ahead. Supernatural theism is inherently flexible in relation to scientific findings and ground-of-being cosmology lines up with those findings as tentative discoveries about the depths of reality, so process cosmology is the only one of the three that can be contradicted by physical cosmology. From some points of view this is a theoretical virtue.
- In respect of furnishing an account of ultimate reality, which is a goal prized by many metaphysically minded philosophers, process cosmology clearly does not even finish the race, while both supernatural and ground-of-being cosmologies provide hopeful and realistic accounts of ultimacy, respectively.
- In respect of being able theoretically to accommodate the variety of philosophical frameworks explored in the world's wisdom traditions, ground-of-being theism is the clear winner, with its shattering of standard distinctions showing that the theoretical divides among major options in philosophical cosmology may be surmountable to some degree. For example, while ground-of-being cosmology directly contradicts the theistic form of supernatural cosmology, it can be seen as a generalization to ultimate reality of process cosmology, and also as compatible with the various discarnate entities of supernaturalism, so long as they receive a (so far not understood) scientific basis in natural processes.
- In respect of overall plausibility relative to the portrayal of nature in physical cosmology, supernatural theism obviously finishes in last place. Process cosmologies do quite well in this regard but face technical problems for which the metaphysical solution within the prehensive theory of causation is not yet clear. Ground-of-being cosmologies finish first because its plausibility derives in part from conforming itself to the outline of reality as sketched in the natural sciences.

Do considerations such as these lend themselves to an overall champion in this three-way competition? Probably not. But there are many other considerations that play a role and, because the patterns described here repeat themselves, I suspect that supernatural cosmology finally falls by the wayside, unable to keep up with the other two worldviews. The choice between process cosmology and ground-of-being cosmology finally turns less on traction with the natural sciences and more on purely metaphysical criteria, such as whether an account of ultimacy is to be prized or shunned in a philosophical cosmology.