

Universe or Multiverse? A Theistic Perspective

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I. Introduction:

In articles published in physics journals, the multiverse hypothesis is strictly regarded from a non-theistic perspective, as a possible explanatory hypothesis for the life-permitting values of the constants of physics. Further, several attempts have been made to draw specific predictions with regard to the values of these constants from a multiverse hypothesis, such as those of Steven Weinberg with regard to the cosmological constant. Such approaches reflect the legitimate methodological naturalism of physics. In wider-ranging philosophical discussions of the multiverse hypothesis as found in various books on the topic, however, the issue arises as to what is relation between the multiverse hypothesis and much larger philosophical issues, particularly whether reality is ultimately impersonal or personal in nature. In such contexts, the multiverse hypothesis is typically presented as the atheistic alternative to a theistic explanation, such as that offered by John Polkinghorne, of the purported fine-tuning of the cosmos for intelligent life. As keeping with the Templeton Foundation's goals for this symposium and the topic of my session (namely, the theological implications of the multiverse hypothesis), I will be addressing both the compatibility of the multiverse hypothesis with theism and the degree to which it provides an alternative to the hypothesis that God designed the universe to bring about conscious, embodied beings such as ourselves. I do not expect necessarily to convince anyone of the theistic point of view, realizing that many factors -- both theoretical and personal-- underlie our views of the ultimate nature of reality. My intention here is simply to sketch some of the reasons why one might think that contemporary physics and cosmology is not only compatible with theism, but that it actually might suggest a theistic explanation of the universe or multiverse.

II. Terminology: God and Multiple Universes

First, we will need to get clear on what I mean by theism and the multiverse hypothesis. With regard to theism, I take the theistic hypothesis to be the claim that an omnipotent and omniscient being is ultimately

responsible for the existence of the universe. The definition of God I would employ would be the so-called Anselmian conception of God, according to which God is defined as the greatest possible being, but this is not essential to my argument. It is often claimed that this conception of God is central to all of the world's theistic religious traditions - Islam, theistic versions of Hinduism, Judaism, and Christianity. As an alternative to the Anselmian conception, one could simply think of the God hypothesis as the minimal hypothesis needed to explain the existence of the universe via some sort of intelligent design: that is, the hypothesis that there exists some highly intelligent and very powerful transcendent agent with the ability to create the universe.

Second, we need to get clear on what we mean by the multiverse hypothesis. There are essentially two versions of the multiverse (or many-universe) hypothesis, what could be called the physical universe-generator versions and what could be called metaphysical versions. In the universe-generator versions, some particular real physical process - such as an inflaton field - is postulated that generates the many universes, whereas in the metaphysical versions the universes are thought to exist on their own without being generated by any physical process.⁽¹⁾ In this paper, I will restrict myself to discussing the physical versions, but the arguments in the last section on the beauty of the laws of nature apply to both versions.

III. The Compatibility Between Theism and Multiverse hypothesis:

So, now to the questions at hand. First, I think that the theistic hypothesis is perfectly compatible with the universe generator versions of the multiverse hypothesis. Since God is infinite and infinitely creative, it also makes sense that creation would reflect these attributes of God, and hence that physical reality might be much larger than one universe. Indeed, it makes sense that an infinitely creative God might create these many universes via some sort of universe-generator, since this would be somewhat more elegant and ingenious than just creating them ex-nihilo. Nonetheless, the idea that the universe is infinite, or there is some multiverse, has often not been stressed in Western theology. A large part of the reason seems to be historical and not intrinsic to the Western theistic conception of God. The highly influential late Medieval theology, for instance, was self-consciously based on an Aristotelean metaphysics. For Aristotle, however, space was defined in terms of the extension enclosed by a physical object - such as the Medieval Crystalline spheres in the case of our universe - which were conceived of as necessarily finite. Only with the eventual questioning of Aristotle by such leading thinkers such as Nicholas of Cusa and later Giordano Bruno did the positive suggestion emerge that space was infinite, with perhaps an infinity of worlds. Thus Bruno declares:

Thus is the excellence of God magnified and the greatness of his kingdom made manifest; he is glorified not in one, but in countless suns; not in a single earth, but in a thousand, I say, in an infinity of worlds. (Koyré, 1957, p. 42.)

This belief in the infinity of our universe was further developed and elaborated by Newton and many of his contemporaries.⁽²⁾

In contrast to the West, the theistic traditions originating in India have traditionally stressed the vastness and eternity of creation. For example, in theistic versions of classical Hinduism, ultimate reality, Brahman, is identified with a personal God, and God is taken as the greatest possible being. The world in turn is identified with a mode of God's being (at least in the Ramanuja form of Hinduism). Since God is infinite, the world will naturally be infinite, with an infinite number of realms of being.

Indeed, the fact that the multiverse scenario fits well with an idea of an infinitely creative God, and the fact that so many factors in contemporary cosmology and particle physics conspire together to make an inflationary multiverse scenario viable significantly tempts me toward seriously considering a theistic version of it. This temptation is strengthened by the fact that science has progressively shown that the

visible universe is vastly larger than we once thought, with a current estimate of some 300 billion galaxies with 300 billion stars per galaxy. Thus, it makes sense that this trend will continue and physical reality will be found to be much larger than a single universe.

Of course, one might object that creating a fine-tuned universe by means of a universe generator would be an inefficient way for God to proceed. But this assumes that God does not have any other motive for creation - such as that of expressing his/her infinite creativity and ingenuity - than creating a life-permitting cosmos using the least amount of material. But why would one make this assumption unless one already had a preexisting model of God as something more like a great engineer instead of a great artist? Further, an engineer with infinite power and materials available would not necessarily care much about efficiency.

IV: Understanding the Fine-tuning Argument

Our second question is, Does the multiverse hypothesis undercut the case for theism from fine-tuning? I will argue that at most it mitigates the case by rendering it less quantitative. First, however, we will need to sketch the fine-tuning argument itself.

The fine-tuning has been widely claimed to provide evidence or at least suggest some sort of divine design of the universe. Elsewhere, I have attempted to develop this argument in a more principled way (for example, Collins, 2002). As I develop it, the "core version" of the argument essentially involves claiming that the existence of intelligent life-permitting values for the constants of physics is not surprising under theism, but highly surprising under the non-design, non-multiverse hypothesis - that is, the hypothesis that there is only a single "universe" and that it exists as a brute fact without any further explanation. Further, the reason it seems highly surprising under the non-design, non-multiverse hypothesis is that, for certain constants of physics, the range of intelligent life-permitting values is purportedly small compared to some non-arbitrarily defined comparison range - such as the range of force strengths in nature when discussing the fine-tuning of gravity and other forces.

Using what I could be called the surprise principle (see next footnote), it follows that the existence of intelligent life-permitting values for the constants provides evidence in favor of theism over the non-design, non-many universes hypothesis.⁽³⁾ A comparison between the theistic explanation and a non-theistic version of the multiverse explanation is then considered separately. Notice that no claim is being made here that theism is the best explanation of the constants being intelligent life-permitting. To judge that an hypothesis is the best explanation of a body of data involves an overall assessment of the hypothesis, not simply how well it explains the particular data in question. The fact that Johnny's fingerprints are on the murder weapon might significantly support the claim that Johnny committed the murder. Nonetheless, Johnny's committing the murder might not be the best explanation of the fingerprints since we might have strong, countervailing evidence that he did not commit the murder. Perhaps, for instance, five reliable witnesses saw Johnny at a party at the time of the murder. Similarly, all I claim is that the evidence of fine-tuning supports theism over the non-design, non-multiverse hypothesis. However, to judge whether we should infer to theism as the best explanation of the structure of the universe - versus simply accepting the universe as a brute given - involves many factors beyond the evidence of fine-tuning.

One of the key claims in the above argument is that the existence of a universe with intelligent life-permitting cosmic conditions is not surprising under theism. This claim needs support instead of merely being assumed in an ad hoc way. Essentially, the argument is that if God is good - an assumption that is part and parcel of classical theism -- then it is not extremely improbable that God would create a world with intelligent beings, because the existence of such beings has positive value, at least under the theistic hypothesis. Philosophers of religion offer a variety of justifications for the claim that God is perfectly good, or at least why ascribing goodness to God is not arbitrary. Here I will simply present two. First, some philosophers appeal to the Anselmian conception of God, arguing that a being that is perfectly good is greater than one that is not perfectly good, and hence he characteristic of perfect goodness should be

ascribed to God. Other philosophers - such as Richard Swinburne - argue that once grasped, the goodness or beauty of a state of affairs gives any conscious agent a reason to prefer that state of affairs; the idea is that part of grasping that a state of affairs has value - whether moral or aesthetic - is to "feel" the desirability of the state, and hence have some motivation to bring it about. Under this view, for instance, people only do evil either because they do not grasp the disvalue of doing evil, or because some other influence tempts them to do what they recognize as having ethical disvalue. Since God is a perfectly free - that is, God is not subject to countervailing desires in the way we are - God would have no motive to act against the good or beautiful. So, we would naturally expect God to act to bring about states of beauty and goodness. Whether one buys this sort of argument or not, I think that at minimum one has to admit that it is in no way arbitrary or ad hoc to hold that God has the desire to bring about states of goodness and beauty.

If this is right, then theism provides a natural connection between the moral and aesthetic realm of value and any such value we might have reason to believe that the universe has the appropriate structure to realize. One need not necessarily invoke a personal God to provide this connection, however. Philosopher John Leslie, for instance, proposes what could be thought of as a "God substitute" what he calls a neoplatonic principle of ethical requiredness, as suggested by Book VI of Plato's Republic. According to this principle, of necessity, what ought to exist does exist. Further, Leslie claims, this principle simply exists as a matter of metaphysical necessity, much as many philosophers view the truths of mathematics, such as that $2 + 2 = 4$. Thus its existence is self-explanatory.

V. Multiverse Generator Needs Design:

In this section, I will argue that even if a multiverse generator exists, the argument for theism from the fine-tuning of the constants for intelligent life is not completely eliminated. The argument essentially goes as follows. The multiverse generator itself, whether of the inflationary variety or some other type, seems to need to be "well-designed" in order to produce life-sustaining universes. After all, even a mundane item like a bread machine, which only produces loaves of bread instead of universes, must be well designed as an appliance and must have the right ingredients (flour, water, yeast, and gluten) to produce decent loaves of bread. If this is right, then invoking some sort of multiverse generator as an explanation of the fine-tuning serves to kick the issue of design up one level, to the question of who designed the multiverse generator.

The inflationary multiverse scenario, widely considered the most physically viable, provides a good test case of this line of reasoning. The inflationary multiverse-generator can only produce life-sustaining universes (or regions of space-time) because it has the following "components" or "mechanisms:"

- 1) A mechanism to supply the energy needed for the bubble universes: This mechanism is the hypothesized inflaton field. By imparting a constant energy density to empty space, as space expands the inflaton field can act "as a reservoir of unlimited energy" for the bubbles (Peacock, 1999, p. 26).
- 2) A mechanism to form the bubbles: This mechanism is Einstein's equation of general relativity. Because of its peculiar form, Einstein's equation dictates that space expand at an enormous rate in the presence of a field, such as the inflaton field, that imparts a constant (and homogenous) energy density to empty space. This causes both the bubble universes to form and the rapid expansion of the pre-space which keeps the bubbles from colliding.
- 3) A mechanism to convert the energy of inflaton field to the normal mass/energy we find in our universe. This mechanism is Einstein's relation of the equivalence of mass and energy combined with an hypothesized coupling between the inflaton field and normal mass/energy fields we find in our universe.

4) A mechanism that allows enough variation in constants of physics among universes: Currently, the most physically viable candidate for this mechanism is superstring or m-theory. Superstring theory might allow enough variation in the variations in the constants of physics among bubble universes to make it reasonably likely that a fine-tuned universe would be produced, but no one knows for sure. ⁽⁴⁾

Without all these "components," the multiverse generator would almost certainly fail to produce a single life-sustaining universe. If, for example, the universe obeyed Newton's theory of gravity instead of Einstein's, the vacuum energy of the inflaton field would at best simply create a gravitational attraction causing space to contract, not to expand.

In addition to the four factors listed above, the inflationary multiverse generator can only produce life-sustaining universes because the right background laws are in place. Specifically, the background laws must be such as to allow the conversion of the mass-energy into material forms that allow for the sort of stable complexity needed for life. For example, without the principle of quantization, all electrons would be sucked into the atomic nuclei and hence atoms would be impossible; without the Pauli-exclusion principle, electrons would occupy the lowest atomic orbit and hence complex and varied atoms would be impossible; without a universally attractive force between all masses, such as gravity, matter would not be able to form sufficiently large material bodies (such as planets) for complex, highly intelligent life to develop or for long-lived stable energy sources such as stars to exist. ⁽⁵⁾

In sum, even if an inflationary multiverse generator exists, it along with the background laws and principles have just the right combination of laws and fields for the production of life-permitting universes: if one of the components were missing or different, such as Einstein's equation or the Pauli-exclusion principle, it is unlikely that any life-permitting universes could be produced. In the absence of alternative explanations, the existence of such a system suggests design since it seems very surprising that such a system would have just the right components as a brute fact, but not surprising under the theistic design hypothesis. Thus, it does not seem that one can completely escape the suggestion of design merely by hypothesizing some sort of multiverse generator.

It must be admitted, however, that if such a multiverse generator could be verified, the sort of quantitative evidence for design based on the fine-tuning of the constants would be eliminated. Whereas the degree of fine-tuning of a particular constant of physics could arguably be assigned a number - such as that corresponding to the ratio of the length of its intelligent life-permitting range to some non-arbitrarily specified "theoretically possible" range - we cannot provide a quantitative estimate for the degree of apparent design in the cases mentioned above. All we can say is that if certain seemingly highly specific sorts of laws were not in place, no life sustaining universes could be generated. Thus, the case for design would be mitigated, although not completely eliminated.

VI. Multiverses, Design, and the Beauty of the Laws of Nature:

Next, I want to look at a much more powerful suggestion of design from modern physics, that arising from the "beauty" of the laws of nature. This suggestion of design completely bypasses the multiverse objection to the design argument, whether that based on the universe-generator or the metaphysical variety of the multiverse hypothesis. First, the idea that the laws of nature are beautiful and elegant is a commonplace in physics, with entire books devoted to the topic. Indeed, Steven Weinberg - who is no friend of theism - devotes an entire chapter of his book *Dreams of a Final Theory* to beauty as a guiding principle in physics. To develop our argument, however, we need first to address what is meant by beauty. As Weinberg notes, the sort of beauty exemplified by physics is that akin to classical Greek architecture. The highpoint of the definition of this classical conception of beauty could be thought of as that of William Hogarth in his 1753 classic *The Analysis of Beauty*. According to Hogarth, simplicity with variety is the defining feature of

beauty or elegance, as illustrated by a line drawn around a cone. Hogarth claimed that simplicity apart from variety, as illustrated by a straight line, is boring, not elegant or beautiful.

The laws of nature seem to manifest just this sort of simplicity with variety: we inhabit a world that could be characterized as a world of fundamental simplicity that gives rise to the enormous complexity needed for intelligent life. To see this more clearly, we will need to briefly explicate the character of physical law, as discovered by modern physics. I will do this in terms of various levels.

The physical world can be thought of as ordered into the following, somewhat overlapping, levels. First, there are the observable phenomena. This is level 1. The observable world seems to be a mixture of order and chaos: There is order, such as the seasons or the order of day following night, but also many unique, unrepeatable events that do not appear to fall into any pattern. Level 2 consists of a set of postulated underlying entities and processes hypothesized to obey some fundamental physical laws. Such laws might be further explained by deeper processes and laws, but these will also be considered to inhabit level 2. So, for instance, Newton's law of gravity and Einstein's equation of General Relativity would be considered at Level 2. One of the great achievements of science has been the discovery that a deeper order to these phenomena could be found in mathematics. As has been often pointed out, the pioneers of this achievement, such as Galileo, Kepler, Newton, and Einstein, had a tremendous faith in the existence of a mathematical design to nature, though as is well known, Einstein did not think of this in theistic terms. As Morris Kline, one of the most prominent historians of mathematics, points out, "From the time of the Pythagoreans, practically all asserted that nature was designed mathematically During the time that this doctrine held sway, which was until the latter part of the nineteenth century, the search for mathematical design was identified with the search for truth." (1972, p. 153.)

Level 3 consists of fundamental principles of physics. Examples of such principles are the principle of conservation of energy and the gauge principle (that is, the principle of local phase invariance), the principle of least action, the anti-commutation rules for fermions, and the correspondence principle of quantum mechanics. These are regulative principles that, when combined with other principles such as that of choosing the simplest Lagrangian, are assumed to place tight constraints on form that the laws of nature can take in the relevant domain. Thus, they often serve as guides to constructing the dynamical equations in a certain domain. Finally, at level 4 is the basic mathematical structure of current physics, for example, the mathematical framework of quantum mechanics, though there is no clear separation between much of level 4 and level 3. Finally, one might even want to invoke a level 5, which consists of the highest-level guiding metaphysical principles of modern physics - principles such as that we should prefer simple laws over complex laws, or that we should seek mathematical explanations for phenomena.

Now, this simplicity with variety is illustrated at all levels, except perhaps level 5. For example, although the observable phenomena have an incredible variety and much seeming chaos, they can be organized via a relatively few simple laws governing postulated unobservable processes and entities. What is more amazing, however, is that these simple laws can in turn be organized under a few higher-level principles (level 3) and form part of a simple and elegant mathematical framework (level 4).

One way of thinking about the way in which the laws fall under these higher-level principles is as a sort of fine-tuning. If one imagines a space of all possible laws, the set of laws and physical phenomena we have are just those that meet the higher-level principles. Of course, in analogy to the case of the fine-tuning of the parameters of physics, there are bound to be other sets of laws that meet some other relatively simple set of higher-level principles. But this does not take away from the fine-tuning of the laws, or the case for design, any more than the fact that there are many possible elegant architectural plans for constructing a house takes away from the design of a particular house. What is important is that the vast majority of variations of these laws end up causing a violation of one of these higher-level principles, as Einstein noted about general relativity. Further, for those who are aware of the relevant physics, it is easy to see that in the vast majority of such cases, such variations do not result in new, equally simple higher-level principles being satisfied. It follows, therefore, that these variations almost universally lead to a less elegant and simple set of higher-level physical principles being met. Thus, in terms of the simplicity and elegance of the higher-level principles that are satisfied, the laws of nature we have appear to be a tiny island

surrounded by a vast sea of possible law structures that would produce a far less elegant and simple physics.

As testimony to the above point, consider what Steven Weinberg and other physicists have called the "inevitability" of the laws of nature. (For example, see Weinberg, 1992, pp. 135-153, 235-237). The inevitability that Weinberg refers to is not the inevitability of logical necessity (1992, p. 235), but rather that the mathematical structure of the laws of nature are encompassed by a few general principles. The reason Weinberg refers to this as the "inevitability" of the laws of nature is that the requirement that these principles be met often severely restricts the possible mathematical forms the laws of nature can take, thus rendering them in some sense "inevitable." If we varied the laws by a little bit, these higher-level principles would be violated.

This inevitability of the laws is particularly evident in Einstein's general theory of relativity. As Weinberg notes, "once you know the general physical principles adopted by Einstein, you understand that there is no other significantly different theory of gravitation to which Einstein could have been led." (1992, p. 135) As Einstein himself said, "To modify it [general relativity] without destroying the whole structure seems to be impossible." (Quoted in Weinberg, 1992, p. 135.)

This inevitability, nor near-inevitability, is also illustrated by the gauge principle, the requirement that the dynamical equations expressing the fundamental interactions of nature - gravity, the strong, weak, and electromagnetic forces - be invariant under the appropriate local phase transformation. When combined with the heuristic of choosing the simplest interaction Lagrangian that meets the gauge principle and certain other background constraints, this has served as a powerful guide in constructing the equations governing the forces of nature. Yet, as Ian Atchison and Anthony Hey point out in their text *Gauge Theories in Particle Physics*, there is no compelling logical reason why this principle must hold (1989, pp. 59- 60). Rather, they claim, this principle has been almost universally adopted as a fundamental principle in elementary particle physics because it is "so simple, beautiful and powerful (and apparently successful)" (1989, p. 60). Further, as Alan Guth points out, the original "construction of these [gauge] theories was motivated mainly by their mathematical elegance" (1997, p. 124). Thus, the gauge principle provides a good example of a contingent principle of great simplicity and elegance that encompasses a wide range of phenomena, namely the interactions between all the particles in the universe.

Theism offers a natural, non-ad-hoc explanation, of why the laws of nature can be encompassed by such principles. As mentioned above it has been part and parcel of traditional theism that God would be motivated to bring about an aesthetically pleasing universe. Can a non-theistic, non-design view of reality offer an explanation? Though we will not argue in detail for it here, it does not seem that one can plausibly think of these principles as in themselves having any causal power to dictate the lower-level phenomena or laws. It is easy to be misled at this point into thinking that they do, however. Because we can derive (with a few additional assumptions) the lower-level laws from the higher-level principle, it is easy to think that somehow these higher-level principles make the lower-level laws what they are. Rather, the "causation" or dependence is in the other direction: it's because the laws and phenomena are what they are that these principles universally hold, not the other way around. An analogy from architecture might be helpful to illustrate this point: insofar as the placement of windows in a building follow higher-level principles, it is not because the principles somehow in themselves have a special power to make the windows have the right positions. Rather, it is because of the position of the windows that the higher-level principles hold. Further, insofar as the higher-level principles could be said to have a causal efficacy to determine the placement of the windows, it is only via the causal powers of an intelligent agent, such as the people who constructed the building.

One reason for claiming that these principles have no intrinsic causal powers is that except for being an intention or thought in some mind, human or transcendent, it is difficult to see how these higher-level principles could be anything over and above merely the patterns into which the laws and phenomena of nature fall. For example, they do not appear to be reducible to the causal powers of actual entities, as some philosophers claim about the laws of nature.⁽⁶⁾ Instead, insofar as entities possess causal powers, the principles describe the arrangement of the causal powers of a diverse class of such entities--e.g., the

fundamental particles--and therefore cannot be the powers of any given entity. And even if they did describe the causal power of some single type of entity - say a superstring,- it would still be amazing that the action of those powers could be captured and unified by a few simple higher-level mathematical rules. This would be analogous to how even if the fine-tuning of the constants of physics for life were to be explained by some grand unified theory, it would still be amazing that the grand unified theory that happened to exist was one that yielded values for the constants that were intelligent life-permitting.

Further, this "fine-tuning" for simplicity and elegance cannot be explained either by the universe-generator multiverse hypothesis or the metaphysical multiverse hypothesis, since there is no reason to think that intelligent life could only arise in a universe with simple, elegant underlying physical principles. Certainly a somewhat orderly macroscopic world is necessary for intelligent life, but there is no reason to think this requires a simple and elegant underlying set of physical principles. This is especially clear when one considers how radically different the framework and laws of general relativity and quantum mechanics are from the world of ordinary experience: although the regularities of the everyday world are probably derived from the underlying laws of quantum mechanics and general relativity, they do not reflect the structure of those laws. Indeed, it is this difference in structure between the classical, macroscopic world and the quantum world that has largely given rise to the interpretive problems of quantum mechanics. Thus, there is little reason based on an observation selection effect to expect the sort of macroscopic order necessary for intelligent life to be present in the underlying, microscopic world.

Finally, the form of argument in this case for design has the same form as that in the case of the fine-tuning of the constants for intelligent life, except unlike in the case of the fine-tuning for intelligent life, this fine-tuning cannot be explained by multiverse hypothesis. One way of putting the argument is in terms of the "surprise principle" we invoked in the argument for the fine-tuning of the constants of intelligent life. Specifically, as applied to this case, one could argue that the fact that the phenomena and laws of physics are fine-tuned for simplicity with variety is highly surprising under the non-design hypothesis, but not highly surprising under theism. Thus, the existence of such fine-tuned laws provides significant evidence for theism over the non-design hypothesis. Another way one could explicate this argument is as follows. Atheism seems to offer no explanation for the apparent fine-tuning of the laws of nature for beauty and elegance (or simplicity with variety). Theism, on the other hand, seems to offer such a natural explanation: for example, given the classical theistic conception of God as the greatest possible being, and hence a being with a perfect aesthetic sensibility, it is not surprising that such a God would create a world of great subtlety and beauty at the fundamental level. Given the rule of inference that, everything else being equal, a natural non-ad hoc explanation of a phenomenon x is always better than no explanation at all, it follows that everything else being equal, we should prefer the theistic explanation to the claim that the elegance and beauty of the laws of nature is just a brute fact.

In conclusion, I am well aware that many aspects of the above argument need to be worked out in more detail - such as the surprise principle and the claim that the simplicity of the laws of nature are highly surprising under atheism. But I hope this paper provides some understanding of not only why a theist might be sympathetic to the multiverse hypothesis, but might even see some of the findings of physics and cosmology as supportive of theism.

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1. I define a "universe" as any region of space-time that is disconnected from other regions in such a way that the parameters of physics in that region could differ significantly from the other regions.
2. A more contemporary Christian writer who has imaginatively developed this theme is the late C. S. Lewis in his fantasy series *Chronicles of Narnia*, in which God is imagined to have created a large number of different realms of being.
3. The surprise principle can be stated as follows. Let H1 and H2 be two competing non-ad-hoc hypotheses: that is, hypotheses that were not constructed merely to account for the data E in question. According to the surprise principle, if a body of data E is less surprising under one of the hypotheses H1 than under the other, H2, then the data E provides evidence in favor of H1 over H2. The best way, I believe, of explicating what the notion of surprise is here is in terms of what philosophers call conditional epistemic probability, in which the above principle is a version of the likelihood principle or the principle of relevance, which is a standard principle of probabilistic confirmation theory. (Unlike what D. H. Mellor (2003) assumes in his objection to Martin Rees's claim that cosmic fine-tuning supports the multiverse hypothesis, conditional epistemic probability is not a measure of ignorance. Rather, it has to do with relations of support or justification between propositions. As the famous economist John Maynard Keynes stated in his treatise on probability, "if a knowledge of h justifies a rational belief in a of degree , we say that there is a probability-relation of degree between a and h." (Keynes, p. 4) Although I think Keynes's account needs to be further worked out, I believe his account is on the right track.)
4. The other leading alternatives to string theory being explored by physicists, such as the currently proposed models for Grand Unified Theories (GUTS), do not appear to allow for enough variation. The simplest and most studied GUT, SU(5), allows for three differing sets of values for the fundamental constants of physics when the other non-SU(5) Higgs fields are neglected (Linde, PP&IC, p. 33). Including

all the other Higgs fields, the number of variations increases to perhaps several dozen (Linde, IQC, p. 6). Merely to account for the fine-tuning of the cosmological constant, however, which is estimated to be fine-tuned to be at least one part in 10^{53} , would require on the order of 10^{53} variations of the physical constants among universes.

5. Although some of the laws of physics can vary from universe to universe in string theory, these background laws and principles are a result of the structure of string theory and therefore cannot be explained by the inflationary/superstring multiverse hypothesis since they must occur in all universes. Further, since the variation among universes would consist of variation of the masses and types of particles, and the form of the forces between them, complex structures would almost certainly be atom-like and stable energy sources would almost certainly require aggregates of matter. Thus, the above background laws seem necessary for there to be complex, embodied intelligent observers in any of the many-universes generated in this scenario, not merely a universe with our specific types of particles and forces.

6. For example, see Rom Harré and Edward Madden, 1975. Under the conception of laws as expressing causal powers, Einstein's Equation of general relativity would be seen as being grounded in the causal powers of matter to bend space-time.