Does the Many-Universes Hypothesis Really Explain the Fine-Tuning?

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I. Introduction

The last thirty years have witnessed a major revival in the philosophical, theological, scientific, and popular literature of the traditional design argument for theism. Probably the most convincing and widely discussed of these arguments is based on the so-called "fine-tuning" of the cosmos, which refers the fact that the parameters of physics and the initial conditions of the universe are balanced on a razor's edge for life to occur. For example, calculations by Brandon Carter indicate that if the force of gravity had been stronger or weaker by one part in 10^{40}, then life-sustaining stars could not exist (Davies, 1984, p. 242); similarly, calculations indicate that if the strong nuclear force, the force that binds protons and neutrons together in an atom, had been stronger or weaker by as little as 5%, life would be impossible. (Barrow and Tipler, p. 322.) As the eminent Princeton physicist Freeman Dyson notes, "There are many . . . lucky accidents in physics. Without such accidents, water could not exist as liquid, chains of carbon atoms could not form complex organic molecules, and hydrogen atoms could not form breakable bridges between molecules" (1979, p. 251)--in short, life as we know it would be impossible.

Many people find this extraordinary fine-tuning of the parameters and initial conditions of the universe as strong evidence for some sort of designer, such as the God of classical theism. For example, theoretical physicist and popular science writer Paul Davies--whose early writings were not particularly sympathetic to theism--claims that with regard to basic structure of the universe, "the impression of design is overwhelming" (Davies, 1988, p. 203). Similarly, in response to the life-permitting fine-tuning of the nuclear resonances responsible for the oxygen and carbon synthesis in stars, the famous astrophysicist Sir Fred Hoyle declares that "A commonsense interpretation of the facts suggests that a superintellect has monkeyed with physics . . . and that there are no blind forces worth speaking of in nature." (Quoted in Davies, 1982, p. 118.)

In response to explaining the fine-tuning in terms of design, however, many atheists have offered an alternative explanation, what I will call the atheistic many-universes hypothesis, where the adjective "atheistic" is included to distinguish it from the theistic many-universes hypothesis. According to the many-universes hypothesis, there are a very large--perhaps infinite --number of universes, where by the term "universe" I mean any region of space-time that is disconnected from other regions in such a way that the constants or laws of physics in that region could differ significantly from the other regions. Furthermore, these universes are postulated to be produced by some "universe generator," and the fundamental parameters of physics are postulated to vary randomly from universe to universe. Of course, in the vast majority of these universes the parameters of physics would not have life-permitting values. Nonetheless, in a small proportion of universes they would, and consequently under this hypothesis it is no longer improbable that universes such as ours exist that are fine-tuned for life to occur.

Although several models have been proposed as to what this "universe generator" could be, currently the most popular one is what I will call the "inflationary many-universes model." According to the inflationary universe model of the big bang--a model currently in vogue among many cosmologists-- the universe arose as a rapidly expanding "bubble" out of a so-called "false vacuum" state of an hypothesized group of interacting quantum fields, called Higgs fields. According to the many-universes version of this model, which is claimed to be a natural extension of it, a very large, if not infinite, number of these bubbles have formed in this false vacuum. Morever, each of these "bubble universes" is postulated to form by symmetry breaking of the Higgs fields, yielding randomly varying values for the initial conditions of the universe and the parameters of physics. Imaginatively, one can think of this superspace of Higgs fields as an infinitely extending ocean full of soap, with each universe as a soap-bubble which spontaneously forms on the ocean.

II. A Critique of the Many-Universes Hypothesis

In the rest of this paper, I will focus on one key problem with the many-universes hypothesis as an ultimate explanation of the fine-tuning: namely, it seems that the "many-universes generator" would need to be fine-tuned, and hence it seems to transfer the problem of explaining cosmic fine-tuning up one level to that of the many-universes generator itself.

In support of this claim, we begin by noting that in all currently worked-out proposals for what this "universe generator" could be, the "generator" itself is not only governed by a complex set of physical laws that allow it to produce the universes, but also requires a set of fine-tuned parameters. Even the so-called "chaotic inflation" many-universes model, which attempts to eliminate some of the fine-tuned initial conditions of the standard inflationary models by hypothesizing that these initial conditions vary at random over the superspace of Higgs fields, cannot avoid the fine-tuning of its parameters. As philosopher John Earman has recently pointed out, "The inflationary model can succeed only by fine-tuning its parameters, and even then, relative to some natural measures on initial conditions, it may also have to fine-tune its initial conditions for inflation to work." (1995, p. 156)

At present, therefore, the chaotic inflation model simply seems to transfer the atheist's problem of accounting for the fine-tuning of our universe up one level. And this is not surprising. After all, even my bread machine has to be made just right--fine-tuned, if you will--in order to work properly, and it only produces loaves of bread, not universes! Or consider a device as simple as a mouse trap: it requires that all the parts, such as the spring and hammer, be arranged just right in order to function. Thus, at present it seems doubtful that the atheistic many-universes hypothesis can provide an adequate ultimate explanation of cosmic fine-tuning.

Nonetheless, it is at least conceivable--though I think unlikely--that in the future a many-universes-generator model could be developed which does not require a fine-tuned set of parameters. This hypothesis of a non-fine-tuned many-universes generator, however, seems to face two major problems, which we will now examine.

Problem #1: The "Natural Extrapolation Rule."

Although one cannot completely rule out the hypothesis of a non-fine-tuned many-universes generator, it does stretch the limits of plausibility and conceivability. Thus, in regard to this hypothesis, I suggest that we should invoke a general rule of reasoning: namely, *everything else being equal, we should prefer hypotheses for which we have independent evidence or which involve natural extrapolations from what we know by experience or from reasonably well-established theories.* Let's first illustrate and support this principle, and then apply it to the hypothesis under consideration.

Most of us take the existence of dinosaur bones to count as very strong evidence that dinosaurs existed in the past. But suppose a dinosaur skeptic claimed that she could explain the bones by postulating a "dinosaur-bone-producing-field" that simply materialized the bones out of thin air. Moreover, suppose further that, to avoid objections such as that there are no known physical laws that would allow for such a mechanism, the dinosaur skeptic simply postulated that we have not yet discovered these laws or detected these fields. Surely, none of us would let this skeptical hypothesis deter us from inferring to the existence of dinosaurs. Why? Because although no one has directly observed dinosaurs, we do have experience of other animals leaving behind bones and other remains, and thus the dinosaur explanation is a *natural extrapolation* from our common experience. In contrast, to explain the dinosaur bones, the dinosaur skeptic has invented a set of physical laws, and a set of mechanisms, that are clearly *not* a natural extrapolation from experience or any well-established theory.

In the case of the fine-tuning , we already know that minds often produce fine-tuned devices, such as Swiss watches. Postulating God--a "supermind"--as the explanation of the fine-tuning, therefore, is a natural extrapolation from of what we already observe minds to do. Now, the inflationary many-universes model could be argued to be a natural extrapolation from reasonably-well established scientific ideas: for example, the many-universes version of the inflationary model is arguably a natural extrapolation of the inflationary model, and the inflationary model, though speculative, could be considered a natural extrapolation of reasonably well-established ideas, such as that of symmetry breaking, in modern particle physics. The hypothesis of a *non-fine-tuned* many-universes generator, however, not only fails to be a natural extrapolation of any well-established theory, but actually goes against what we know regarding the need for fine-tuning in all currently developed many-universe models and what we know about the need for fine-tuning from common experience, such as the bread machine example given above. Accordingly, just as with the dinosaur-bone-producing field hypothesis, the simple conceivability of a non-fine-tuned many-universes generator is not a sufficient reason to take it seriously. By the "natural extrapolation" principle, therefore, we should prefer the theistic explanation of the fine-tuning over the non-fine-tuned many-universes generator explanation, everything else being equal.

Problem #2: **The Apparent Design of the Laws of Physics**

Even if such a many-universes model could be developed that dispensed with the need for fine-tuned parameters, the atheist would still need to account for the apparent fine-tuning of the laws of physics: just as the right values for the parameters of physics are needed for life to occur, the right set of laws also seem to be needed. If, for instance, certain laws of physics were missing, life would be impossible. For example, without the law of inertia, which guarantees that particles do not shoot off at high speeds, life would probably not be possible (Leslie, Universes, p. 59). Another example is the law of gravity: if masses did not attract each other, there would be no planets or stars, and once again it seems that life would be impossible. Yet another example is the *Pauli Exclusion Principle*, the principle of quantum mechanics that says that no two fermions--such as electrons or protons--can share the same quantum state. As prominent Princeton physicist Freeman Dyson points out (1979, p. 251), without this principle all electrons would collapse into the nucleus and thus atoms would be impossible. In terms of the laws governing the inflationary scenarios themselves, one not only needs the basic laws of quantum mechanics (such as the Schrodinger equation, the commutation relations holding between the operators for position and momentum, and the eigenvalue/eigenvector rule which says that the only allowed values of an observable are the eigenvalues of its associated operator), but one also needs a large number of specially constructed fields. Indeed, according to Alan Guth, the simplest inflationary model requires 24 interacting Higgs fields, a set of associated algebraic operators for the strong, weak, and electromagnetic interactions, and a set of additional quantum fields corresponding to the various types of particles in the universe. (1997, p. 139).

How might advocates of the atheistic many-universes hypothesis respond to this "fine-tuning" of the laws problem? Let's look at three responses they could give.

Response 1:

First, they could hypothesize the existence of a "super many-universes generator" that allows for a random variation of laws of physics themselves in some superspace. As John Polkinghorne notes, atheists could speculate that "the laws of nature themselves fluctuate so that a vast portfolio of conceivable or (to us) inconceivable worlds rise and fall in a relentless explosion of random possibility..." (1998, p. 9). Polkinghorne quickly dismisses this suggestion as a "rash and desperate" claim that has "moved beyond anything that could be called scientific..." (p. 9). I would like to consider the problems confronting this proposal in a little more depth, however, since even though it seems implausible to us today, we cannot simply rule it out: after all, quantum mechanics would have seemed enormously implausible to a classical physicist of the 19th century, yet it is the cornerstone of modern physics.

The first problem with this proposal is that the universe generator itself would have to obey some set of laws, at least if it is to be meaningfully thought of as a physical thing in any sense analogous to the physical things in our universe. So, we would still have the problem of apparent design: why the set of laws that allow for such fluctuations instead of laws that would be sterile, such as those of classical mechanics. Suppose, however, that we ignore this problem. A further problem with this proposal is the simplicity, beauty, and elegance of the laws of physics in our universe. Consider, for instance, the simplicity of Newton's law of gravity, $F = Gm_1m_2/r^2$. Among other things, the exponent of r, the distance between two masses, is "2," which clearly has a simpler form than, for instance, an irrational exponent.[(1)] Yet, since the irrational numbers are infinitely more numerous than the integers (or rational) numbers, if laws were being randomly generated, one would expect our laws to typically have irrational exponents, not integer or rational ones. Similar things could be said about the simplicity of the Schrödinger equation, or of Einstein's field equation of general relativity which is often recognized as having been chosen by Einstein because of its simplicity. So, it seems that to get the superuniverse generator hypothesis to account for the simplicity of the laws of nature, one would further have to hypothesize that it was "constructed" in such a way that it was much more likely for the laws to fluctuate over simple laws than complex laws. Moreover, to account for the beauty, elegance, harmony and seeming ingenuity of nature recognized by such prominent physicists as Albert Einstein, Paul Dirac, and Steven Weinberg (e.g., Weinberg, 1992, chapter 6, "Beautiful Theories.") one would have to postulate that the laws also tended to fluctuate over those that were particularly elegant and harmonious. These assumptions, however, seem very *ad hoc*.

A final problem that this superuniverse generator hypothesis is that unlike in classical physics, many of the "laws" of quantum mechanics are not expressible as equations governing the relation between various physical quantities, but rather as "rules." One can at least conceive of how the equations, such as Einstein's field equation of general relativity, could actually express real physical relations between various quantities, and thus exist in some sort of multi-dimensional physical space. Specifically, one could imagine a space of functional relationships linking various quantities, such as mass and spacial curvature, with the superuniverse fluctuations occurring over that space. Although one probably would run into severe mathematical problems--such as the existence of a natural, non-arbitrary ordering of the functional relationships, and a natural measure for them--one could conceive of these being surmountable. It is much more difficult, however, to conceive of how a "space of rules" could be physically meaningful. Consider, for instance, the quantum mechanical rule that all states are to be represented as vectors in Hilbert space, and that to each observable there corresponds a unique Hermitian operator; or consider the eigenvalue/eigenstate rule that says that the only allowed values of an observable are the eigenvalues of its corresponding operator; or consider the probability rule that says that the probability of the measurement of an eigenvalue E of an observable O is proportional to the square of the coefficient of its corresponding eigenstate in a spectral expansion of the state for that observable; or finally, consider the various so-called "superselection " rules that restrict the allowed quantum states, such as that underlying the Pauli Exclusion principle that says that the joint state of any two identical fermions must anti-commute. Each of these rules, and others like them, place constraints on the possible states, the form of the operators, the form of the equations, and the relations between the states, operators, and results of measurement. It is difficult to see how one could even go about formulating these rules in such a way that we could meaningfully conceive of a physically existing space of such rules, with each rule representing some physical relationship over that space. This, however, is what would be needed in order or the superuniverse generator to select the rules.

Admit tingly, one cannot completely rule out the above superuniverse generator hypothesis. Nonetheless, it does stretch the limits of plausibility and conceivability. Hence, it seems that the "natural extrapolation" rule explicated above applies to this hypothesis with particular force.

Response 2:

Perhaps, however, advocates of the many-universes explanation of the fine-tuning could simply deny that the laws are "fine-tuned" in any way that is relevantly analogous to the fine-tuning of the parameters of physics. So, whereas they admit that the existence of life-permitting values for the parameters of physics needs an explanation, they could deny this in the case of the laws. Specifically, they could argue that in the case of the fine-tuning of the parameters of physics, we can quantitatively estimate the degree of fine-tuning--for example, one in 10^{40} in the case of the gravitational constant. Thus, we have an objective basis for saying that such fine-tuning is in itself improbable and in need of explanation. In contrast, atheists could argue, we have no way of quantitatively estimating the degree of fine-tuning of the laws of physics, and thus our basis for saying that it is improbable, or in need of explanation, is less objective.

Although admittedly our basis is less objective, it is still significant. First, we do have an objective basis for claiming that the laws are fine-tuned: we can make solid, scientific arguments that certain laws--such as the *Pauli Exclusion Principle* mentioned above--are necessary for intelligent life. Second, we can often judge that a system that requires many interrelated elements for it to function is unlikely to have arisen by chance, even though we have no *quantitative* basis for our judgement of unlikelihood. For example, most people--whether atheists are theists-- would agree that it is very unlikely that complex body organs such as the heart, eye or wing could have arisen merely by chance (without natural selection). And they would agree with this assessment whether or not we have a quantitative basis for it. This is why, as Richard Dawkins notes, before Darwin it was impossible to be "an intellectually fulfilled atheist" (1986, p. 6), for it seems part of human rationality to demand explanations of complex, interrelated systems, many of whose elements are necessary for some seemingly meaningful purpose. The system of laws uncovered by physicists, however, seem to be such a system of interrelated elements.

Response 3:

A third way advocates of the many-universes hypothesis could respond to the apparent "fine-tuning" of the laws of physics is by claiming that, as far as we know, there could be a single, fundamental law underlying the hypothesized many-universes generator, even though current models of the universe generator must hypothesize a seemingly "well-designed" set of interrelated laws.

Besides being entirely speculative, the problem with postulating such a law is that it simply moves the improbability of the fine-tuning of the laws of physics up one level, to that of the postulated physical law itself. Under this hypothesis, what is improbable is that of all the conceivable, simple fundamental physical laws there could be, there just happens to exist the one that results in a universe generator that produces life-sustaining universes. Thus, trying to explain the fine-tuning of the laws by postulating this sort of fundamental law is like trying to explain why the pattern of rocks below a cliff spell "Welcome to the mountains Robin Collins" by postulating that an earthquake occurred and that all the rocks on the cliff face were arranged in just the right configuration to fall into the pattern in question. Clearly this explanation merely transfers the improbability up one level, since now it seems enormously improbable that of all the possible configurations the rocks could be in on the cliff face, they are in the one which results in the pattern "Welcome to the mountains Robin Collins." And this holds whether or not we include as part of our hypothesis that the configuration of rocks on the cliff face was "simple" or "complex."

III. Conclusion:

In light of the above considerations, I conclude that it is doubtful for a variety of reasons that the many-universes hypothesis can avoid simply transferring the problem of explaining the cosmic fine-tuning up to the level of the universe generator itself.

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1. As physicist Arnold Sikkema pointed out to me, one might argue here that there are reasons of internal consistency why the exponent of Newton's law must be "2," and hence that of necessity the universe generator could not produce universes in which the gravitational force did not obey something like an inverse square law. The answer to this objection begins by first noting that the exponent of "2" can be thought of as following from the fact that the gravitational field can be represented in terms of a potential that obeys Poisson's equation. Since the gravitational field, or potential, can be represented in this way, it follows from the divergence theorem and the fact that we live in a three-dimensional space that the exponent of "r" must be "2." Hence, if the exponent of "r" was something other than "2," it follows that gravity could *not* be represented in terms of a potential that obeys Poisson's equation. But, it does not follow from the inability to represent gravity as such a potential that it is inconsistent for the exponent of "r" to be something other than "2" for r.

Changing the exponent of "r," of course, would also have consequences for other equations in physics. For example, if we consider general relativity to be the correct theory of gravity, then the fundamental equation of general relativity relating mass with space-time curvature (Einstein's equation) would have to be different if some other exponent than "2" occurred in Newton's law. The reason is that it follows from Einstein's equation that in the Newtonian limit--that is, those ordinary situations where Newton's law is known to be valid--that the force of attraction can be represented in terms of a potential that obeys Poisson's equation (See Wald, 1984, pp. 76-77 for derivation). No doubt, if the exponent of "r" were something other than "2" in Newton's law of gravity, the fundamental equation of general relativity would probably need to be much more complex than it is. As is, however, the equations governing gravity are "doubly simple": Einstein's equation is well-known for its simplicity, and when the Newtonian limit is taken of Einstein's equation, it yields a further equation that it also simple. Thus, one has a harmonious network of simple equations.

Finally, it should be noted that changing Newton's law might also have further physical consequences for other equations in physics, thus affecting the whole network of equations of physics. (Of course, whether this is the case will have to await a theory of quantum gravity, something we do not have yet.) From this larger perspective in which each equation is seen as part of an interlocking network of equations, however, the problem of simplicity still remains: namely, Why does the super-many-universe generator produce a physically consistent network of equations each of which displays such simplicity?