Is Our Finely-Tuned Universe Improbable?

Abstract: In this paper we argue that given some reasonably plausible metaphysical assumptions, it follows that a randomly chosen possible world would be *nearly certain* to contain at least one universe fine-tuned for the evolution of biological life. Thus, if these assumptions are correct, then it may follow that the fine-tuning of our universe is not actually at all improbable.

I. The Equal Probability Assumption

In a famous address in 1996 titled "Why is There Anything at All?" Peter van Inwagen argued that the probability of *something or other* existing is much higher than the probability of nothing existing at all. The argument for this conclusion rests on two key claims. First, that there is at most one possible world which is entirely empty.[1] Second, that "for any two possible worlds, the probability of their being actual is equal" (van Inwagen 1996: 99.) Van Inwagen spends the majority of his paper defending this second claim, which we shall call the 'Equal Probability Assumption.' Some philosophers have objected to this claim on the grounds that simpler possible worlds (e.g., those that include only a single proton) would seem to have a higher *a priori* probability than highly complex possible worlds (e.g., ours).[2] In this paper, we will not directly address the truth of the Equal Probability Assumption, instead we seek to show that surprising conclusions follow if this assumption is combined with other independently plausible assumptions.

The conclusion that we will focus on is the claim that given the Equal Probability Assumption, it follows that the probability of a universe fine-tuned for the evolution of intelligent biological life is actually highly probable—in fact, it is as probable as anything can be. This claim is both independently interesting and important to debates related to the Fine-Tuning Argument for God. The most important objection to the Fine-Tuning Argument is the Multiverse Hypothesis. This hypothesis claims that there may in fact exist many universes and so the fact that *one* such universe is fine-tuned is in no way surprising. There are many versions of the Multiverse Hypothesis each with different strengths and weaknesses. The most common objection to the Multiverse Hypothesis is that they cannot be formulated without thereby invoking another higher order kind of fine-tuning for the inclusion of life-evolving universes. Only a small number of possible multiverses, it is argued, would include in them any life-evolving universes. Thus, it would

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[1] As noted later, we are assuming an "abstractionist" conception of possible worlds and not a realist one.
[2] Kotzen 2013.

seem that multiverses are fine-tuned for the inclusion of life-evolving universes in much the way that individual universes are supposed to be. Thus, it has been argued by a number of philosophers that the supposition of a multiverse is not a genuine alternative to theism in explaining why our universe is fine-tuned for the evolution of intelligent biological life.[3] A variant of this objection has been made recently by Klass Landsman, who writes,

> if anything, a Multiverse would make fine-tuning ever more puzzling. Taking the firing squad analogy, there is no doubt that the survival of a single executee is unexpected, but the question is whether it may be explained (or, at least, whether it becomes less unexpected) by the assumption that simultaneously, many other 'successful' executions were taking place. From the probabilistic point of view … their presence should have no bearing at all on the lone survivor, whose luck remains as amazing at it was.[4]

The basic idea here seems to be that supposing a lot of life-less universes (or successful executions) does not all-by-itself seem to increase the likelihood of a life-evolving universe (or unsuccessful execution.) The fact that there is at least one life-evolving universe would presumably be as surprising as it was before. In this paper, we show that this objection to the Multiverse Hypothesis is mistaken because given the Equal Probability Assumption a Multiverse Hypothesis can be defended without invoking a higher level fine-tuning for the inclusion of life-evolving universes. In this way, we will show that given certain philosophical assumptions the Multiverse hypothesis can stand as an alternative to the Theistic hypothesis in explaining the fine-tuning of our universe.

II. Our Surprisingly Probable Universe

We begin our argument with three definitions and two assumptions. Let us begin with the definitions:

Physical Universe - a set of physical objects such that each member of the set bears some spatio-temporal relation to all other members of the collection.[5]

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[3] See McGrath 1996:124. Many theistic philosophers have also argued for the compatibility of theism and the multiverse theory. For a good bibliography of the relevant arguments and critiques see Kraay 2015: 9.
[4] Landsman 2015: 11.
[5] Given these above definitions it would seem as though space and time were themselves necessary because they exist in all possible worlds. But this is not correct because this definition refers only to physical universes. Furthermore, if there is an empty universe then it may not have space or time. This definition does, however, commit us to the claim that space and time are necessary for the existence of physical objects. If one objects to this claim, then we believe that it would be relatively easy to reformulate the definition to avoid this implication.

Possible World - a complete description of everything that exists (with no restrictions on the quantifiers).

Multiverse – a possible world with more than one physical universe in it.

We note that our definition of 'physical universe' is very similar to David Lewis's definition of 'possible world.'[6] This is not an accident, of course, but while we will argue that there may exist more than one physical universe, we do *not* believe that these other universes are themselves possible worlds. That is, we believe that these other physical universes have nothing to do with the metaphysics of modality itself, but rather are simply different members of one particular possible world (namely, the actual one). This assumption has to be made by anyone who rejects Modal Realism and yet believes that multiverses are logically possible.

Based on these definitions we then make the following two assumptions:

I. *Multiverse Assumption* – Multiverses (that is, possible worlds which include more than one physical universe) are possible.

II. *Unrestricted Combination* – There are no logical restrictions on which physical universes can be combined into multiverses.

From these two claims it follows that there must be a non-enumerable infinite set of possible worlds. To show this imagine a list of all atomic propositions which can be true at an individual physical universe. It does not particularly matter for our purposes what we take these atomic propositions to be, but they are all of the propositions such that every possible *physical universe* can be described by a proper subset of these propositions. Let us assume, as seems highly plausible, that there are a countable infinite number of atomic propositions. Imagine these atomic propositions listed in some fixed order. Now take '1' to indicate truth and '0' to indicate falsity. Any possible *physical universe* can now be encoded by a string of 1s and 0s. There are a non-enumerable infinite number of such strings, but not all will encode physical universes, because some of the elementary propositions might contradict each other. For example, the propositions 'There are exactly 24 protons in the universe' and 'There are exactly 10^{24} protons in the universe' cannot be true in the same physical universe.

[6] Lewis 1986.

This leaves open the question of how many strings of 1s and 0s lead to internally consistent sets of propositions: only finitely many, enumerably infinitely many, or non-enumerably infinitely many. Rejecting the idea that there are only finitely many consistent descriptions of possible physical universes as implausible, we still have no way of knowing whether the set of possible physical universes is enumerable or not. For the purposes of simplicity of exposition of the mathematics to follow, we will assume that this set of possible physical universes is indeed enumerable. However, all of the mathematical conclusions we will draw apply equally if the set of possible physical universes is not enumerable; the probability theory involved just becomes much more technical.

Because we have assumed – solely for the sake of exposition – that the set of consistent descriptions of physical universes is enumerable, we can name these infinite *strings* of 1s and 0s which encode different possible universes 'u_1, u_2, u_3, …' etc. So u_1 is the name of an infinite string of 1s and 0s that encodes a possible physical universe.

Now let us assume that multiverses are possible and that there are no restrictions as to which physical universes can be combined in any one possible world. From this it would follow that every possible combination of universes exists in some possible world. Thus, the set of all of the possible worlds would be the *power set* of the set of all physical universes. But we know from Cantor that the power set of any set is always larger than the original set. Thus, we know that, regardless of whether the set of internally consistent descriptions of physical universes was enumerable or not, there must be a non-enumerable infinite set of possible worlds. From this claim, it follows as well that there are a non-enumerable infinite set of multiverses. (The set of single-universe possible worlds has the same cardinality as the set of possible physical universes, and the set of all possible worlds is infinitely greater than this cardinality.)

In the above argument, we have not said anything particularly controversial. It is generally believed that the set of possible worlds is non-enumerably infinite. We have simply given another reason for accepting this claim. Now let us turn to van Inwagen's Equal Probability Assumption in light of what we have said above. Let us assume that each possible world is equally probable *a priori*. Now let us imagine that we choose a possible world *entirely at random*. How probable is it that this possible world will include within it at least one physical universe which is fine-tuned for the evolution of intelligent biological life? Let us begin to answer this question by assuming that only a tiny percentage of the possible physical universes are so fine-tuned. Let us say that only 1 in every 10^{50} such physical universes are fine-tuned in this way.[7] Let us also stipulate, for the sake of simplicity, that in our list of all of the possible universes <u_1, u_2, u_3, …> every 1 in 10^{50} universes on this list is fine-tuned for the evolution of intelligent biological life. Let us now define a set F, which is the set of all and only those universes which are fine-tuned so as to make the evolution of intelligent biological life possible. That is, to form set F we take every 1 in 10^{50} of the universes encoded on our list. So F = $\{u_{10^{50}}, u_{2 \times 10^{50}}, u_{3 \times 10^{50}}, \ldots\}$ We can now rephrase our question to: What is the probability that a randomly chosen possible world will include at least one physical universe which is *also* a member of set F?

To answer this question, let us encode *possible worlds* in much the same way as we encoded physical universes. A possible world will be encoded as a string of 1s and 0s such that if the first physical universe encoded in our list above <u_1, u_2, u_3, …> is a member of the possible world then the first member of the string encoding that possible world is a '1', if the second physical universe is not included then we get a '0' in the second place, etc. In this way, each *possible world* can be described as a string of 1s and 0s. So each possible world can be encoded in much the following way:

P = 101100….

Just to be clear: whereas when encoding *physical universes* a '1' indicates a true proposition and a '0' indicates a false one from our imaged list of all atomic propositions, when encoding *possible worlds* a '1' indicates that a given universe exists in that possible world and '0' indicates that that particular universe does not exist in that possible world. Given the assumption of Unrestricted Combination we can infer that every infinite string of 1s and 0s defines a unique possible world. The string of 1s and 0s encoding a possible world will have to be infinite because there are an infinite number of possible universes.

[7] There is a technical issue here that should be acknowledged: Saying that a property holds for a specific fraction of an enumerably infinite set is not mathematically consistent. Note that the '1 in n' formulation of our list depends on the wholly arbitrary order in which the elements were listed. Although the exposition is simpler under the assumption that the set of consistent descriptions of physical universes is enumerable, some of the mathematics is actually simpler under the assumption that it is not, which is, to us, the more plausible case. But we do not believe that anything of significance turns on this technical issue. With somewhat more complex mathematics the argument can be reformulated with a non-enumerable set. The essential philosophical intuition is, however, the same. All that is required is that the set of physical universes which are fine-tuned for the possible evolution of intelligent biological life not be finite

Now let us take a randomly chosen possible world P. How probable is it that this particular possible world P includes at least one physical universe which is also a member of F? To answer this question, we just need to check each place in the string encoding P which indicates a physical universe that is also a member of F and see if it has a '1'. If it does, then P includes a physical universe that is also a member of F. If none of those places has a '1', then P does not include any physical universes that are also members of F. Ignoring all but the relevant digits in the string, we still have an infinite list of 1s and 0s, each chosen independently and at random. Since there are an infinite number of relevant digits, the probability of *every single one* of them coming out 0 in a randomly chosen possible world is 0.[8] Thus, the probability that *at least one* of the relevant digits is a 1 is 100%, or as likely as anything can be.

Now this argument assumes that the probability of any particular universe being included in any given multiverse is ½. However, just because each universe has the same probability (Equal Probability Assumption) it does not follow that that probability is 50%. Thus, it may seem as though we have smuggled into our analysis a quite dubious probabilistic assumption. But this assumption is not as important as it might first seem to be. Given the claim there are an infinite number of life-evolving universes (that F is infinite) so long as each universe as some positive probability of being included in the multiverse, the overall probability of none of them being included is 0. So even if each universe has a 1 in a trillion probability of being included in any given multiverse—so we imagine a process that is still random but assigns 0 a trillion times more often than a 1 for each digit in our possible world encoding string—given an infinite number of chances there is a 0 probability of an infinite string of them all coming out 0. The situation is entirely different, however, if we assume (as seems very improbable) that the number of life-evolving universes is finite. The relevant formula here $(1-1/n)^x$ where 1/n is the probability of the occurrence in each instance and x is the number of independent chances of that event occurring. So, assume that each universe has a 1 in a million chance of being included in the actual world. Also assume that there are only a million life-evolving universes. Even in this case the probability of getting an actual world *without* a life-evolving universe is only 37%, so it is more likely than not that a life-evolving

[8] For those not familiar with mathematical probability theory, the distinction between 'probability 0' and 'impossible' might be novel. These are distinct concepts; of course, anything impossible has probability 0 but the converse is not true. If a real number is chosen at random from among all real numbers, what are the odds of it being π? While it is not impossible, the odds are, in a technical sense, 0 or as improbable as anything can be without being impossible.

universe will be included in any randomly chosen possible world. Nevertheless, the philosophical significance here seems to be minimal because it relies on the highly dubious claim that there are only a finite number of life-evolving universes. With an infinite number of such universes, the exact probability of each being included does not matter (as long as there is some chance.)

What does all of this mean? It means that if we take any randomly chosen possible world, then there is a 100% probability that it will include at least one physical universe which is fine-tuned for the evolution of intelligent biological life. Thus, if we suppose that which possible world is actual is determined randomly, then given the Equal Probability Assumption, it would be extremely surprising if a universe fine-tuned for the evolution of intelligent biological life did *not* exist as part of that possible world. So, the existence of a fine-tuned universe like ours may not be at all improbable given the Equal Probability Assumption.

We can now see where Klass Landsman's objection goes astray. The claim that there would be some life-evolving universe or other (given the assumptions noted above) is not surprising. But it is surprising that this particular life-evolving universe is in the actual world. Nevertheless, this surprising fact can still be explained by random chance. To modify the firing squad analogy, it is as if each in an infinite number of firing squads was shooting randomly and each had the same probability of missing the prisoner. In such a case, we would expect some prisoner or other to survive. The fact that it was (say) John Smith is indeed unexpected. But this surprise is no more remarkable than the claim that john Smith is the winner of a fair lottery. The event can be both surprising and explained by a randomness.

III. Corollary: There is Also a 100% Probably That We Live in a Multiverse

One other interesting result easily follows from the above reasoning. Given that a physical universe like ours does actually exist, we can infer that it almost certainly exists as part of some multiverse or other. The reasoning here is similar to the above reasoning. Let us suppose that our universe is encoded in the list of physical universes at place n. Let us now make a list of all of the encoded possible worlds which include n as a member. There will be an infinite number of such possible worlds. But only *one* such possible world will include a 1 in place n and a 0 in all other places. We only have access to our universe, of course, so all that we know is that one of these infinite number of possible worlds is actual, but from our vantage point we have no way of knowing which one. Given the Equal Probability Assumption, we can infer that each of the infinite number of possible worlds which includes our universe is equally probable *a priori*. So, consider the infinite list of encoded possible worlds with a 1 in place *n*. What is the probability that a randomly chosen member of this list includes a 0 in all other places other than *n*? The probability would obviously be 0 or as improbable as anything can be without being impossible. Thus, we can infer that if which possible world is actual was determined randomly, we can expect both that a multiverse would exist and that a life-evolving physical universe would exist as a member of that multiverse.

IV. Conclusions

There are many possible conclusions one could draw from the above reasoning. One could, of course, use this argument as part of an argument for rejecting the Equal Probability Assumption, Multiverse Assumption, or Unrestricted Combination Assumption. Of these three we believe that the Equal Probability Assumption is probably the most dubious. But we see no compelling objection to it. Similarly, if one could give good reason for believing that our universe does *not* exist as part of a multiverse, then we could infer in the above way that the probability that our universe came into existence by random chance is 0. (Because if it had come into existence by chance it is overwhelmingly likely that it would exist as part of a multiverse.) But neither of us knows of a good reason to reject the idea that our universe exists as part of a multiverse.

One consequence does, however, follow concerning the current debate about the Fine-Tuning Argument for God. If the reasoning in this paper is correct, then given the Equal Probability Assumption, the Multiverse Hypothesis *can* be invoked as an explanation of the fine-tuning of our universe for the evolution of intelligent biological life *without* thereby invoking a higher level of fine-tuning for the inclusion of life-evolving universes. While many particular Multiverse Hypotheses seem clearly to invoke a higher level of fine-tuning for the inclusion of life-evolving universes (e.g., supposing multiverses with universes that vary *in just the right way* that a life-evolving universe is sure to be included in it), there is at least one version of the hypothesis that does not do so.

Works Cited

Goldsmidt, Tyron. 2013. *The Puzzle of Existence.* Routledge

Kotzen, Matthew. 2013. "The Probabilistic Explanation of Why There Is Something Rather Than Nothing" in Goldsmidt 2013: 215-235.

Kraay, Klaas J. ed. 2015. *God and the Multiverse: Scientific, Philosophical, and Theological Perspectives* Routledge.

Landsman, Klaas. 2015. "The Fine-Tuning Argument." Available at https://arxiv.org/abs/1505.05359.

Lewis, David. 1986. *On the Plurality of Worlds*. Blackwell.

McGrath, Alister E. 1996. *A Fine-Tuned Universe: The Quest for God in Science and Theology.* WJK Press.

van Inwagen, Peter and E. J. Lowe. 1996. *Proceedings of the Aristotelian Society, Supplementary Volumes.* Vol. 70: 95-120.