A Simple Universe Argument

Virgil Șerbănuță*

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Abstract

This paper argues that if our universe is not designed, it should have a high level of a certain kind of complexity that should be visible everywhere. Given that we don't observe this, our universe is most probably designed. Moreover, it's probably designed for intelligent beings.

Virgil

This is valid regardless of how many universes exist, whether it is one, or all logically possbile ones, or anything in between.

1 Introduction

There is a common belief that there are certain laws approximating our universe's behaviour fairly well, that we can compute its age, that we can make predictions about the distant future, and so on. In a way, all of these are really surprising. In the words of Feynman (2009):

> Incidentally, the fact that there are rules at all to be checked is a kind of a miracle; that it is possible to find a rule, like the inverse square law of gravitation, is some sort of miracle. It is not understood at all, but it leads to the possibility of prediction — that means it tells you what you would expect in an experiment you have not yet done.

This paper attempts to figure out statistically why we observe such a surprising universe and what we can reasonably believe about it.

This argument can be considered a statistical approach to Aquina's fifth way. It tries to avoid some of the issues that other statistical approaches attempting to show that our universe is designed (e.g. the fine-tuning argument) have.

To be specific, it is arguing that, in the context of all possible universes that could have human-like beings, our universe is extremely unlikely unless a Designer intended it, and, even more, probably the Designer wanted to design for human-like beings.

In order to show this, we first need to specify what would count as a universe. This is a difficult question in general, but, fortunately, this paper's argument also works if we take into account only a subset of all possible universes. In particular, we only need to take into account universes that are able to sustain intelligent beings, and, assuming that they contain intelligent beings, there should be mathematical theories (called "descriptions") that these beings could use to predict (either fully, or as an approximation) how their universe behaves. We allow both deterministic and non-deterministic universes.

*design-and-chance@poarta.org

Section 3 introduces these notions in a more rigorous way, together with some of the reasoning behind them.

Section 4 presents the main issues discussed in this paper.

Just defining the notions presented in section 3 is not enough, we also need to make some assumptions about our universe and about the link between mathematical theories and reality.

First, we specify what it means to observe events with probability 0, generalizing this to the case when there is no probability modelling how we observe the event. Next, we assume that our universe can be modelled by a finite-dimensional space based on the real numbers, or by something close to that. We also assume that it is possible to approximate the behaviour of the space around us, which is isotropic enough. We also need to assume that the set of possible universe descriptions is large enough, i.e. it has the same size as the set of real numbers.

Section 5 contains axioms for all the assumptions mentioned above, each with an argument explaining why the axiom makes sense.

Having these, we can start the main part of the argument, which says that, in the context of all possible universes that could have human-like beings, our universe is extremely unlikely unless a Designer intended it, the most obvious reason for that being that the Designer wanted to design for human beings.

The main issue is that our universe seems to behave according to relatively simple laws that do not change with time and space. That is completely implausible if it happens by chance, so there should be an explanation for it. If our universe is not designed, then the other possible explanation is that there is something outside of our universe that made it likely for our universe to exist (called a meta-universe). However, it turns out that a meta-universe that would explain our universe is also unlikely, and would itself need an explanation, so there should be a meta-meta-universe explaining the meta-universe, which would also need an explanation, and so on, until we get an infinite chain of meta-universes. But this chain would also need an explanation, so perhaps there is a meta-infinity universe that explains it. Since this meta-infinity universe would also need an explanation, we can continue this process for quite a while, which makes these meta-universes also implausible.

This means that, if our universe is not designed, then it will not behave according to simple laws, and, in principle, we should be able to notice it. However, with our current travelling means, we can observe only a limited part of our entire universe, so it is possible that we live in a bubble covering a large amount of time and space, in which simple laws apply.

Even if that is the case, our universe is still unlikely among all possible universes containing such bubbles, because our bubble is much larger than it needs to be. A conservative estimate produces a probability so low for our universe, that almost any other explanation is preferable.

It's harder to estimate the same probabilities when there is a Designer, but it is likely that the probability for our universe is much higher than in the non-design case.

Section 6 describes this argument in detail.

Section 7 presents some clarifications and possible answers to various objections to this paper. Section 8 presents this paper's argument conclusion.

This paper uses some mathematical notions related to set cardinalities, probabilities and ordinals, which can be found in, e.g., Bagaria (2020), Cohen (1966) and Billingsley (1995). These are summarized in section 9, together with some properties derived from them.

2 The Ordered Universe Argument

The great Catholic theologian Thomas Aquinas, in his "fifth way", attempts to show God's existence from the order of the universe, i.e. that almost all bodies, almost always behave according to simple natural laws. One can find a good exposition of this argument in "The Argument from Design"(R. G. Swinburne, 1968), but let us look at a few ideas which are interesting in the context of this paper.

There are two types of order one may consider for showing God's existence, the spatial order and the temporal order. The former is the order that can be seen in (a part of) the universe at a given moment in time, e.g. that planets, living bodies, and other things are ordered. The latter can be seen in the behaviour of things, including the laws of nature, and it's the one that will be used in this paper.

While it addresses many possible objections to Aquinas' fifth way, "The Argument from Design" leaves one of them open: this argument is based on an analogy between the order of the world and the order produced by people, which limits its strength. I think that this paper's argument, although it builds on the same foundation, needs only a fairly weak analogy (see Section 6.4).

The following quote from R. G. Swinburne (1968), made when addressing Hume's objection that the order which can be observed in this universe is just an accident, makes a nice introduction for the argument described in this paper:

> But if we say that it is chance that in 1960 matter is behaving in a regular way, our claim becomes less and less plausible as we find that in 1961 and 1962 and so on it continues to behave in a regular way. An appeal to chance to account for order becomes less and less plausible the greater the order.

3 Possible Universes and Their Descriptions

If our universe is designed, then it's likely to be the way it is because its Designer wanted it to have certain properties. In order to understand why our universe works the way it does, one would need to understand the intent of its Designer. While that is interesting in itself, I will not try to pursue it here, except for a few limited ideas.

For most of the remainder of this paper, let us consider the other case. Let us assume the hypothesis that our universe is not designed and let us try to make a prediction based on it. How would a non-designed universe look like? Would it be similar to our universe? Maybe an infinity of universes exist and ours is just one of many, or maybe our universe is the only one that exists. Even if ours is the only one, one could easily imagine that it worked in a different way, e.g. maybe some constant like the speed of light would be different, or maybe gravity would work differently.

There are people who claim that all logically possible universes exist, either because they think that it simply makes sense, or because they want to give a good account of modality, or for other reasons. If that's the case, it seems, at first sight, that making predictions about non-designed universes is rather hard. However, this paper argues that there are certain things that can be said regardless of how many universes exist, whether it is one, or all logically possible ones, or anything in between.

A possible universe could have exactly the same fundamental laws as ours, but with matter organized differently. It could have similar laws, but with different universal constants. It could have different fundamental particles (or fields, or whatever the basic building blocks of our universe are, assuming that there are any). Or it could be completely different, i.e. different in all possible ways.

It could be that our logic and reasoning are universal instruments, but it could also be that some of these possible universes are beyond what our reasoning can grasp and others have properties for which our logic is flawed. Even if that's the case, let us see if we can say anything about the possible universes that we could understand and could model in some way.

In the following, the **possible universes** term will denote only the logically possible universes which we could model (with a few more constraints that will be added below). However, the word "possible" is ambiguous, so when the distinction between logical possibility and actual possibility is important, the **conceivable universes** term may be used instead.

This notion of model is not precise enough. Let us restrict the possible universes term even more, to the possible universes that could be modelled mathematically, even if that may leave out some of them. This may seem too restrictive, especially since this paper only needs universes which can be approximated by mathematical models. We are going to relax this when talking about approximations, but, for now, let us consider only universes which are modellable with sets of axioms that are at most countable.

Let us restrict the universes we are considering even further, to universes that have something remotely resembling time and space, for which "the state of the universe at a given moment in time", or something close, makes sense, and which can plausibly contain intelligent beings. Any such universe is, for the purpose of this paper, a conceivable universe.

To keep the exposition simple, in the following I will use "the state of the universe at a given moment in time", but one should replace it with one's favourite alternative concept, e.g. with "the state of a hyperplane whose points only have spacelike intervals between them".

Let us define a **universe description** to be a consistent mathematical theory that has a set of axioms which is at most countable and which allows making predictions about the future state of the universe given its state at a certain moment in time. A **universe region description** is something similar, but limited to a given space-time region of a universe, with extra axioms to take into account interactions with the rest of the universe (e.g. by using the state of the region boundary when predicting). In the best case, for a deterministic universe, there might exist a description which allows one to correctly predict the entire future given the state of the universe at some moment in time, but a universe description as defined here does not have to predict everything and, even when it predicts something, it does not have to always be correct.

"Predicting", as used above, would normally mean that one starts from the theory and does some formal inferences and computations, having the prediction as the result. However, as Calude, Meyerstein, and Salomaa, 2012 shows, there are many things that can't be proven this way. We don't know if the state of the universe at a given moment in time is one of those things, although we could restrict our descriptions to ones where this is possible, at least up to a reasonable level. Regardless, let us use a different meaning: a theory predicts something if that something is true in all mathematical models of that theory (i.e. all sets in which the theory's axioms are satisfied).

Note that usually the data available for making predictions is dependent on who is making the prediction. As an example, if we assume that all predictions are about things that can be perceived, directly or indirectly, then each kind of intelligent beings (e.g. humans) will make predictions about the universe as seen through their senses. If a universe contains multiple kinds of intelligent beings, with different kinds of sense organs, then that universe may have descriptions which are very different. Of course, things that are not observable directly can sometimes be mapped to things that are observable, but this may not always be true.

In order to handle this dependence on who observes the universe in a reasonable way, in the remainder of this paper we will work with universes that contain intelligent beings, and all predictions will be relative to what these intelligent beings could observe. If there are multiple kinds of intelligent beings in the universe, whenever we are talking about its description we will assume that we picked one such kind. I.e. although we will talk about universes and their descriptions, we'll actually mean (universe, intelligent-being-kind) pairs and their corresponding descriptions.

Next, let us try to specify how good a universe description should be. First, predictions speak about the future, but expecting to predict everything until the end of the universe (if any) may not be reasonable. We may want to fix an amount of time Δt, focusing on predictions about things that are at most Δt in the future. Second, we shouldn't expect to be able to describe everything with full precision, so we may want to have a precision $\eta > 0$ for all the values that are predicted. Third, we shouldn't expect predictions to always be correct, so we should require that they are true with probability $p > 0$. The exact meaning of "true with probability" here is left open, except that we require p to be the same for each location where predictions are being made. Of course, we may add other similar constraints if needed.

As an example, we could ask that, out of all predictions that we can make at a given spacetime location, a fraction of p turn out to be true. If we are making statistical predictions, then the observed outcomes would be consistent with a fraction p of all sentences representing statistical predictions being correct.

Then let us say that an **approximate universe description** with a **level of approximation** $L = (\eta > 0,\ p > 0 \text{ and } \Delta t > 0)$ is a universe description which allows approximating the future state of the universe with a precision η, with a probability $p > 0$ for a prediction to be correct and for a limited amount of time Δt.

There is a distinction that we should make. When predicting (say) weather we can't make long-term precise predictions, and this happens because weather is chaotic, that is, a small difference in the start state can create large differences over time. This would happen even if the universe would be deterministic and we would know the laws of the universe perfectly, as long as we don't know the full current state of the universe. However, high precision predictions may be possible for a deterministic universe if the full state is taken into account and, as mentioned, we assume that we know that full state when making predictions.

For a given universe or region of a universe, given a level of approximation, we will pick a canonical description in the following way: Let S be the set of descriptions which approximate the universe with the given level of approximation. If S contains at least one finite description, then we pick the shortest such description as "the canonical description", breaking ties by using the lexicographic order. Otherwise, we simply say that the universe (region) has an infinite description, and we will abuse the terminology a bit by picking the entire set S as the canonical description (we could also pick a random description from the set). If the level of approximation is obvious from the context, we will call this canonical description **the universe's description** or the **universe region's description**.

One could also use a well-ordering on the set of real numbers to choose the lowest description as the universe's description, but that would complicate things without any benefit.

4 Options for Our Universe

The remainder of this paper will analyze what we can reasonably believe about the following issues:

- Our universe is designed or not.
- Our universe has a finite or infinite description.
- There is an uncountable chain of meta-universes, in which our universe is the first one, and in which any meta-universe includes, directly or not, all the previous ones.
- The set of possible descriptions for a finite chunk of space-time that are also compatible with life has at least the cardinal of the set of real numbers, $\mathbb{R}$, or a smaller one.

5 Axioms

5.1 Observing Events

In the main argument we will try to use the fact that the set of laws describing the behaviour of our universe is a member of a large set of universe descriptions, a set large enough to have the same cardinality as the set of real numbers.

For sets with the same cardinality as real numbers, the most natural probability distributions are the continuous ones, i.e. probabilities for which any element of the set has probability 0. Practically, this means that we would lose any bet which we would make on a single element of the set.

In order to make some sense out of this, we will use two terms, "generic" and "peculiar", which are defined precisely in section 9.1. Informally, an object is peculiar if it satisfies a peculiar predicate, and a peculiar predicate is one that has a zero probability for any continuous probability distribution. As an example, "has a finite number of digits" is a peculiar predicate over real numbers, and any real number with a finite number of digits, like 12.5, is peculiar. An object or predicate is generic if it is not peculiar.

Axiom 1 below specifies this in a more formal way.

However, it might happen that, for some of the sets used in this paper, no reasonable probability distribution can be defined. Axiom 2 specifies how choice works in those cases.

Throughout this paper we will implicitly use only separated probability measures, i.e. they can measure singletons (single-element sets).

Axiom 1. *If P is a probability over the set of real numbers*[1] *(or a set with the same cardinal)*[2]*, we observe a real number x, and $P(x) = 0$, then x is generic.*

The set of events for which $P(y)$ is greater than 0 is at most countable (see section 9.1), and, if we remove them from $\mathbb{R}$, what remains will still have the same cardinality.

On this later set, the probability of all peculiar events taken together is 0, so there is no chance of us observing one. In other words, the probability of all generic events is 1[3], so we can be sure that we observed a generic event.

Of course, the (logical) possibility of observing a peculiar event still exists, but, practically, we will not observe it as long as the set of our observations is at most countable.

Axiom 2. *If we observe a specific real number x, when we could have observed any real number, and there is no probability distribution that could describe how x was chosen, then x is generic.*

Note that this axiom does not say that we do not know that probability distribution, it says that there is no such probability distribution. Anyone believing that this cannot happen should treat the cases where this axiom applies as invalid.

Also note that this cannot happen when using subjective probabilities.

If there is nothing that could favor peculiar numbers over generic ones, it's absurd to think that we could have observed an element of such a tiny set among something infinitely larger. Also, the similar axiom for probabilities above suggests that this is the only reasonable assumption in this case.

5.2 $\mathbb{R}^4$ Universe

The universes we are interested in are universes that can be modelled on top of a finite-dimensional space based on real numbers, or something close enough to that.

In order to not define what "close enough" means, we will use the following axiom, which is true for any finite dimensional space based on the set of real

[1] Note that here, and in all the axioms in this paper, it is not required that P is a probability over the Borel algebra of $\mathbb{R}$, although that, in many cases, people implicitly assume it when talking about probabilities over $\mathbb{R}$.

[2] Readers should keep in mind that, in most cases throughout this paper, what is being said about the set of real numbers is similarly valid for any set with the same cardinality.

[3] This requires that, in the original set, the set of elements with 0 probability has itself a non-zero probability, or, in other words, that the sum of all probabilities $P(y)$ that are greater than 0 is less than 1. However, if the sum of all these $P(y)$ would be 1, then, no matter how much we try, we would only observe y numbers with $P(y) > 0$, so we would not observe a number x with $P(x) = 0$, as the axiom requires.

numbers, but it also works on spaces based on, say, the set of rational numbers, and on many similar finite dimensional spaces.

Let us define a **generalized rational number** as being either a rational number, or one of $-\infty$ and $+\infty$. Let us denote by "cuboid" a corner-based shape in the n-dimensional space (we could take it to mean "hyperrectangle", "hypercube", or any similar shape).

Axiom 3. *The set of (generalized) cuboids using the same dimensions as our space-time and whose corners' coordinates are generalized rational numbers (i.e. they belong to $\mathbb{Q} \cup \{-\infty, +\infty\}$), is countable and covers our universe.*

Note that any spacetime based on real numbers, i.e. included in $\mathbb{R}^\alpha$, will be included in the generalized cuboid having its corners at plus or minus infinity.

The axiom above does not require the space-time to include the cuboids or their corners. If, say, our universe is based on the set of integers, i.e. it would be included in $\mathbb{Z}^\alpha$, we could consider it as being included in $\mathbb{Q}^\alpha$, where we could check if it is included in one of the cuboids mentioned above.

The following definition could also be written as an axiom.

Definition 1. *A part of our universe is **finite** if it can be covered with a finite cuboid, i.e. one for which all corner coordinates are rational numbers.*

There are a lot of possible definitions for "finite" which are not covered by this definition. While this paper could probably be extended to also handle many of these, most likely there is no point in doing so. As an example, in $\mathbb{R}^3$ one can define it as "having a finite volume", which would mean that there are finite things that do not fit in finite cuboids. In order to handle this, when defining a level of approximation, we could allow ignoring what happens in a small part of the region we model.

5.3 Logically Possible Universes

The following axiom states that, for a given level of approximation, there is a large set of conceivable universes, which in some narrow respects are similar to ours, but which are, in general, wildly different. Also, our universe belongs to this set.

Axiom 4. *For any level of approximation L above a certain minimum level (see below) there is a set D_L of universe descriptions such that the following are true:*

1. *D_L has the same cardinality as the set of real numbers, $\mathbb{R}$.*
2. *For all descriptions d in D_L there is at least one conceivable universe U_d which*
   (a) *is based on time-space or something similar enough;*
   (b) *can plausibly contain intelligent beings that use mathematics;*
   (c) *for the intelligent beings mentioned above and for the level of approximation L, d is U_d's description.*
3. *A description can be used only for its universe, i.e. if d and d' are descriptions from D_L, then d does not work for $U_{d'}$, the universe corresponding to d'.*

4. D_L contains a description for our universe.

The same is true for universe regions, except that D_L may have a lower cardinality.

The minimum level for which this is true is left unspecified, but we should include some common-sense restrictions, e.g. the minimum length we would need to measure is not below Planck's length. All levels of approximation used below will be above this minimum level, even if this is not mentioned explicitly.

To see why this axiom is reasonable, we will first show that our universe's description could be part of such a set, then we will identify a large set of descriptions that fulfils all the requirements except for containing our universe's description, then we will show that, by removing some of the descriptions in that set and adding ours, we get a set that fulfils all requirements.

Let us note that, most likely, we have an approximate description for the observable part of our universe given by classical mechanics, maybe with some additions. Alternatively, one could use a description based on, say, quantum field theory.

We can assume, then, that there is a description, (possibly different from the one above), that works for our entire universe, as we are theoretically able to observe it. In the worst case, the description would be just a recording of what we would observe (i.e. at a given time, in a given place, a certain event takes place).

For almost any countable axiom system that still has an n-dimensional real space, $\mathbb{R}^n$, as a base, one could imagine an alternate universe which, in the present, is exactly like ours inside (say) the orbit of Mars, but what is outside of this orbit is described by that axiom set.

Some of these axiom sets would describe laws of nature which are similar enough to ours to allow us to observe what happens outside of the orbit of Mars, but different enough that we would notice (e.g. gravity could work differently, depending on the region of space in which one travels). Some of them would also allow life to exist inside the orbit of Mars (this is not a given, since, e.g., the zone outside of this orbit may produce large quantities of heat which would make sure that inside the orbit only hot gas or plasma exists).

So we could then try to take all hypothetical universes with infinite space or time, and we could split them into an infinite number of regions. If we take all ways of having sets of laws (descriptions) which are different enough for these regions, we get a set of universes whose set of descriptions has the same cardinality as the set of real numbers and which fulfils all conditions of the axiom above except the last one.

To be more precise, for any approximation level L, and any region that is not trivial for L (the meaning of "trivial" is left open, but, as an example, if we use an approximation level that does not distinguish things smaller than a size l, then the region must be significantly larger than l), there are multiple possible descriptions that are different enough for L, i.e. there is no possible region where both descriptions would be valid within the level of approximation L (see 7.3). We can find two descriptions that are not valid for the region of space around us, which means that they are different enough from any approximate description that we would use.

By splitting an infinite timespace into disjoint regions defined by a set of finite rational coordinates (e.g. we could split it into cubes whose edges have length 1 and whose corners are integers) and taking all possible ways of assigning descriptions to these regions we get a set of universe descriptions with infinitely countable axioms which we will denote by D_L. Since the set of regions is countable, and we can assign at least two descriptions to each region, we get a set of assignments with the same cardinality as $\mathbb{R}$ (also see 9.3).

This does not change if we identify a region that can sustain intelligent life, whose description is fixed, and we require that the other regions' descriptions are compatible with life in the fixed region.

Also, let us note that, from the way we constructed it, we can add our universe's description to this set without breaking any of the requirements.

This means that the set of descriptions mentioned in the axiom, D_L, has the cardinality of $\mathbb{R}$. See section 7.2 for another take on this issue.

Also see (Manson & Thrush, 2003), which suggests that something similar might be happening in our universe.

5.4 Neighbourhood Modelling

Since currently we can not observe our entire universe, saying that it has a high level of complexity is of limited use. The second part of our argument will try to draw some conclusions from what we see in the observable part of our universe. In order to do that, we need an axiom saying that, around us, perhaps in the entire observable part of our universe, there is a relatively simple set of laws that describe it.

Axiom 5. *There is a large compact time-space region of our universe which includes our solar system, and there is a level of approximation L such that:*

1. *Any cuboid included in that region has a finite approximate description for the level L (i.e. we can make non-trivial approximate predictions in all such cuboids).*

2. *A description for one of the cuboids also works for all other cuboids with the same size in the given time-space region (i.e. the space region is isotropic enough).*

Usually we assume, implicitly or explicitly, that this is true, and, even more, that a cuboid's description works for the entire universe. This is especially visible when, e.g., claiming that the universe is around 14 billion years old, that the sun will, in some distant future, become a white dwarf, or that standard-candle supernovae are not illusions. In order to believe this, one must assume that our universe has a finite approximate description or, at least, that our solar system/galaxy/observable part of the universe has such a description.

6 Valid Options for Our Universe

This section will try to develop the axioms above in order to find out what is reasonable to believe about the issues presented in section 4.

We will focus mostly on what happens when our universe is not designed since in this case it is easier to make predictions about our universe and to falsify them, but we will also take a look at created universes.

R. G. Swinburne (2003, Section “Why a world with human bodies is unlikely if there is no God”) comes sort of close to the argument presented here, but while he argues that human bodies are unlikely, I am arguing that, in the context of all possible universes that could have human-like beings, our universe is extremely unlikely unless a Designer intended it, and, even more, the Designer wanted to design for human-like beings. Since the existence of human bodies is not directly related to the subject of this paper, I will not discuss that section more than it is strictly needed.

Note that R. G. Swinburne (2003) says that individual sets of laws have non-zero probability while I'm claiming that their probability is 0. It seems to me that this paper implicitly assumes that such a set has a finite number of laws, while I am explicitly removing that constraint, so both can be right within their contexts.

6.1 Peculiar Descriptions and Meta-universes

6.1.1 Informal argument

From what we observe around us, it seems that our universe is fairly homogenous, having a relatively simple approximate description. In this section we will try to see how plausible it is that this description (or any finite description that still approximates what we see around us) applies to the entire universe, not only the space and time around us. To do that, we will first note that a finite description is peculiar, which means that there is no chance of us observing it both in the case when we use a continuous probability distribution over universes (axiom 1), and in the case when we can't use any probability distribution (axiom 2).

This result should probably be good enough, and if you agree with this, please skip to section 6.3. Otherwise, the only option left is that the correct probability distribution used over universe descriptions is discontinuous. That, in itself, is not enough, because if our universe's description is not one of these discontinuities, then its probability is still 0, which, from axiom 1, means that it's still generic.

If our universe is not designed, then we don't normally have any reason for using a discontinuous probability distribution. For many people this may be enough to show that any approximate description for our universe's description is infinite, and it should settle at least the case when this probability distribution is a subjective one.

However, we will look deeper into this issue. Let us assume that there is a probability distribution over universe descriptions, and that this probability distribution has discontinuities, and that our universe's description is such a discontinuity.

First, we can ask ourselves why there is a probability distribution over universe descriptions. A probability distribution means that which universes exist and which do not, and how many of each type exist, is not completely chaotic, i.e. there is a minimal amount of order among them. We will call this order a “meta-universe”, and we will say that this meta-universe includes our universe, but keep in mind that the usual intuition is that a meta-universe is something more complex than just a minimal amount of order. On the other hand, the most natural explanation for this order that does not involve design is an actual meta-universe, which may contain many other universes besides ours. To put this entire paragraph in fewer words, the probability distribution over universe descriptions is something determined by something we will call a "meta-universe", which includes our universe.

Now we have something that explains this probability distribution, which, as mentioned above, is not continuous. Then we can ask ourselves if this distribution's discontinuities are what we would normally expect or not. It is natural to ask whether we have a probability distribution telling us what we should expect from these discontinuities, and what kind of probability distribution it would be.

The set of discontinuities for a probability distribution is at most countable (see section 9.1), so, if they are described by a continuous probability distribution, or if there is no such probability distribution, we would expect them to be generic. Since our universe's description is one of them, then it should be generic.

Since it's not generic, we can try to explain it (or its discontinuity in the meta-universe) using a discontinuous probability distribution over discontinuities, and assuming that our universe's description is also one of the discontinuities for this new probability distribution. Having this probability distribution would mean that there is a meta-meta-universe that includes the meta-universe and, indirectly, our universe.

But, by using the same reasoning, having peculiar discontinuities for the meta-meta-universe probability distribution is plausible only if there is a meta-meta-meta-universe with a discontinuous probability distribution. By repeating this reasoning, we get an infinite chain of meta-universes, each with a discontinuity for our universe's description. Applying the same reasoning as above to this chain, this discontinuity must be generic, unless there is something explaining it, i.e. a meta-infinity universe, whose probability distribution has a discontinuity for our universe's description.

In order to make this chain more precise, we will assign a number corresponding to the meta-level of each meta-universe. We will assign 0 to the meta-universe including ours, 1 to the meta-meta-universe including (directly or indirectly) the meta-universe and our universe, 2 to the next level, and so on. Then we can denote by ω the meta-infinity universe that explains why all the meta-universes corresponding to finite numbers have a certain discontinuity.

But, if the ω meta-universe probability distribution has a peculiar discontinuity, then it also needs an explanation, so, again, either our universe's description is generic, or there is a meta-universe with a discontinuous probability distribution that includes the ω meta-universe. We will call this the $\omega + 1$ meta-universe.

In the same way, we need meta-universes corresponding to $\omega + 2$, $\omega + 3$, and so on. I.e., we get another infinite chain of meta-universes, which also needs an explanation, which should be provided by another meta-universe, including this second chain. We will call it the $\omega + \omega$ meta-universe or the 2ω meta-universe. But this new meta-universe still needs an explanation, which means that we also need meta-universes corresponding to $2\omega + 1$, $2\omega + 2$, ..., and, in the end, corresponding to 3ω. Next, we will need meta-universes corresponding to 4ω, 5ω, and so on. But to explain this (doubly) infinite chain, we need another meta-universe which we will call $\omega\omega$, or ω^2.

Continuing, we will need meta-universes up to ω^3, then up to ω^4, and so on. In the end, we will need one for the entire infinite chain, denoted by ω^ω. However, we can't stop here, and we will not be able to stop for quite a while.

Each of these meta-universes corresponds to a statistical observation and, as long as we make a countable number of observations, we either expect to observe generic discontinuities, or we expect to find yet another meta-universe above everything that we have observed so far.

This construction corresponds to ordinals, see Cohen (1966), Section 3, to find out more. The process will break at the first uncountable ordinal (let us call it ω_1), since we would make uncountable many observations, one for each ordinal between 0 and ω_1.

So, in order for our universe description to have a chance to be finite, we have to postulate a fairly improbable and complicated configuration of meta-universes and probability distributions, which, in itself, does not seem reasonable. However, even if we postulate it, the probability of our universe description is, most likely, still 0.

To show that, let us note that in this entire construction, the probability of our universe description can be obtained by multiplying the probabilities given by each meta-universe. However, it is unreasonable to ask that any of these probabilities is 1, since 1 is a peculiar value.

It may be difficult to multiply an uncountable set of numbers, but, since these numbers are between 0 and 1, then whatever value we should assign to their product should be less or equal than the product of any countable subset.

If a countable subset of probabilities are all below a certain threshold, say, 0.9, then multiplying them produces 0, which, again, would mean that our universe's description is generic. To have a chance of having a peculiar description, for any threshold less that 1, there should be at most a finite number of probabilities less than it.

Let us take a countable sequence of thresholds, e.g. 0.9, 0.99, 0.999, ..., each of which has a finite number of probabilities less than it. If we take all of the probabilities which are below at least one such threshold together, we will get a countable set. But note that each number less than 1 is below at least one such threshold, which means that the set of probabilities which are not 1 is countable. Also, since the entire set of probabilities is uncountable, we must have an uncountable set of distributions for which our universe description has probability 1.

Each meta-universe probability distribution only gives the probability that a certain description is a discontinuity, i.e. that the probability of that description should be greater than 0, but does not say anything about the probability itself, so we should expect these probabilities to be distributed in a random way, perhaps uniformly distributed between 0 and 1. This means that it is completely implausible to have almost only probabilities that are 1. It is also completely implausible that, when looking at the probabilities which are not 1, for any threshold below 1, only a finite number are below that threshold.

Postulating that such an improbable and complicated construction exists does not seem in any way reasonable, so any description for our universe must be peculiar.

Next section will contain most of this argument, presented in a more formal way.

6.1.2 Formal argument

Let us denote our universe's description by $OURD$. Let us take D_L to be the set of descriptions from axiom 4, with $OURD$ belonging to D_L. As mentioned above, let us also consider that, perhaps, our universe is contained in a meta-universe, which is, perhaps, contained in a meta-meta-universe, and so on, and let us label these meta-universe with ordinal numbers, starting with 0 for the first meta-universe.

If one of these meta-universes does not exist, then obviously, no meta-universe that would include it exists. A less obvious conclusion is that, if one meta-universe does not exist, then there is a "least meta-universe" that does not exist, i.e. a meta-universe that does not exist, but all meta-universes that would be included (directly or not) in it exist[4]. Let us denote this meta-universe by α. Note that, if no meta-universe exists, then $\alpha = 0$. If all meta-universes exist, then let us denote by α a meta-universe labelled with a large enough ordinal, say, the first uncountable ordinal (an ordinal or a meta-universe is countable if the set of ordinals or meta-universes included in it, directly or not, is countable).

Next, let us take a possible meta-universe MU whose ordinal is at most countable, and is not 0, and let us ask ourselves how likely is it to observe that all meta-universes included, directly or not, in it have a discontinuity for the same peculiar universe description, let us call it U.

Any such common discontinuity would be generic if MU does not exist (axiom 2), or if MU's probability distribution is continuous (axiom 1), or if the probability distribution is discontinuous, but it does not have the same peculiar discontinuity U (also axiom 1). The only case when all the universes included in MU have U as a (peculiar) discontinuity is when MU exists and its probability distribution also has U as a discontinuity.

We know that the 0 meta-universe has a discontinuity for our universe's description, and our universe's description is peculiar, so, from transfinite induction (Cohen (1966), section 3), if the first meta-universe, corresponding to ordinal 0, has a peculiar discontinuity, then all countable meta-universes exist, and have the same discontinuity.

6.2 Partial conclusion

As shown in the argument, in order to claim that our universe's description, $OURD$, is peculiar, we would need to postulate the existence of an uncountable chain of meta-universes, all of them favouring a peculiar $OURD$, which, by default, is prohibitively unlikely for any of them. Even more, almost all of them should be extremely favourable to $OURD$, i.e. its probability should be 1.

Although we cannot expand the chain of universes when it becomes uncountable, intuitively the peculiarness problem still remains: why would it suddenly become reasonable to make only peculiar observations if we make enough of them? A few, maybe, but all of them? Normally, when we make observations with a continuous probability distribution, which is the default, we expect to observe only generic elements as long as we make a countable number of obser-

[4] In any set of ordinals one can find the smallest ordinal as ordered by inclusion. In our case, we take the set of meta-universes that would be included in that non-existing meta-universe and, which, themselves, do not exist. Then we can find the smallest meta-universe that does not exist. Since it's the smallest, then all universes that would be included in it exist.

vations, and only when the observation set becomes uncountable we expect to, perhaps, also observe some peculiar elements.

From now on, I will assume that the possible objection in the preceding paragraph is unreasonable, which means that, practically speaking, either $OURD$ is generic or our universe is designed.

Since we don't know the limits of our universe, and how similar the entire universe is to the part we can observe, let us consider next what happens for universe regions.

6.3 Peculiar Descriptions for Universe Regions

In this section we will try to show that it is implausible to have a large region of spacetime around us whose behaviour is described by the same laws of physics that apply here on Earth. How implausible depends on how many distinct descriptions can a finite region of space have in a universe that contains intelligent beings.

We have then the following two cases:

1. The set of descriptions for a finite region such that human-like life can exist in the universe has the same cardinality as $\mathbb{R}$.

2. The same set has a lower cardinality.

Only one of these can be true, but we do not know which one, so we should normally consider only the worst case. However, the first case is plausible, and there is a more efficient way of settling it, so it will be treated separately.

In the first case we can apply the same argument as in section 6.1. The main difference would be the way we assign ordinals: the region would correspond to the universe in the previous argument, our universe would correspond to 0, the first meta-universe would correspond to 1, and so on. I.e. we would treat the region as a universe and our universe as the region's meta-universe.

We can then apply the previous argument to, say, the observable universe, or to the solar system – both should have an infinite description. However, this contradicts axiom 5, so either the set of descriptions for a finite region must have a lower cardinality, or our universe is designed.

Let us focus now on the case when the set of descriptions mentioned above has a cardinality lower than $\mathbb{R}$.

First, let us note that our universe has a generic approximate description, while the region around us has a finite (which means peculiar) approximate description (axiom 5). This means that we can't extend our region's description to the entire universe, which means that there is at least one finite region in our universe with a different description. Even more, if we split our universe in a countable set of finite regions (say, cuboids of the same size), it is not plausible that all of them except a finite set have the same description: for the same reasons as in the previous section, the pattern that we get when we map cuboids to their descriptions should also be generic. However, if all these regions except a finite set have the same description, then we can define this mapping using a finite number of words (i.e. "region X has the second description, region Y has the third description, ..., and all the other cuboids have the first description", where we use the actual description instead of the words "nth description"), and the “can be uniquely identified using a finite number of words” predicate is peculiar.

Let A be the set of possible approximate descriptions for a cuboid of size, say, $1\ second \times meter^3$. Unless our approximation level is extremely coarse, A will have multiple elements. We will assume that we are working with a reasonable approximation level, for which A has more than one element. For any possible description d in the set A, let $P(d)$ be the probability of encountering a cuboid with d as its description in our universe.

If A is finite, we should, by default, pick the uniform probability distribution on A, assigning equal probabilities to all elements of A. However, A can have an infinite cardinal, so we have to consider more general probabilities.

In any case, since A has multiple elements, and since, as mentioned above, if we split our universe into finite regions (i.e. cuboid of size, $1\ second \times meter^3$) then there will be at least two descriptions that each belong to an infinite number of regions, we can't reasonably expect to have one element with probability 1. Then let $p_1 < 1$ be the probability of the description that we use for the cuboids around us. The probability of observing n non-overlapping cuboids with this description without observing any other description is[5] p_1^n.

Even if p_1 is very close to 1, p_1^n converges quickly to 0. As an example, if $p_1 = 0.9$ then observing $n = 70$ consecutive cuboids with the same description is enough to make p_1^n go below one to one thousand odds, $n = 140$ is enough to go below one to one million, $n = 210$ goes below one to one billion. However, let us consider that, say, Mars has a volume of more than $10^{20} meter^3$, so, for each second in which it behaves according to the same laws of physics that work on Earth, it decreases the probability that our universe is not designed by a very large number[6].

Then, if we compare the non-design hypothesis with another one non-zero probability, almost always the consistency of a relatively small spacetime region around us is enough to make the non-design hypothesis unlikely enough to disregard[7].

Next, let us see what happens if we assume the design hypothesis.

6.4 Design Probability

Let us examine the hypothesis that our universe is designed. In this case, the way our world works would be based on the designer's intent, so it is no longer obvious that continuous probability distributions should be the default option for universe descriptions.

[5] This assumes independence between the cuboids, but, given that our universe's description is a generic one, chosen among all possible ones without a Creator biasing it, this is a reasonable assumption.

[6] Using $p_1 = 0.9$ as before, for each second, it decreases the probability that our universe is not designed by more than 1 to $10^{3*(10^{18})}$, that is a 1 followed by $3 * 10^{18}$ zeros.

[7] Let ND be the hypothesis that our universe is not designed, D be the hypothesis that it is designed, $OURD$ be our universe's description, *our* be the description for the region of space around us. Note that $P(our) \geq P(OURD)$ since *our* occurs in any universe having $OURD$ as its description, but may also occur in other universes. We will try to show in section 6.4 that $OURD$ has a non-zero probability if our universe is designed, which would mean that $OURD$ has a non-zero probability in general, so $P(our) \geq P(OURD) > 0$. From Bayes' rule, $P(D|our) = \frac{P(our|D)\cdot P(D)}{P(our)} > 0$. Similarly, $P(ND|our) = \frac{P(our|ND)\cdot P(ND)}{P(our)} = \frac{P(ND)\cdot p_1^n}{P(our)}$. To compare the two we have to compare $P(our|D) \cdot P(D)$ with $P(ND) \cdot p_1^n$.

On the other hand, it is also not obvious that we have a better option. Objections to previous similar arguments include that, from a natural theology point of view, one can't know what the Designer wanted (e.g. one can't know that a universe designer would want to create a universe having life) (Sober, 2009; Narveson, 2003), so, by default, any argument showing that the probability of our universe is small if it's not designed would also show that the probability is small even if it is designed. To fix this, one would need an independent way to show that the Designer wanted the universe to have life (Sober, 2008).

In order for this paper's argument to work, one would actually need a weaker requirement, i.e. it would be enough to have a non-zero probability to the hypothesis that the Designer wanted the universe to have intelligent life. If we cannot do that, then this argument can't explain that the universe around us seems to be consistent. Instead, it would just point out how extremely odd it is to observe it.

It would be possible to argue for an analogy between us and an intelligent Designer of worlds, saying that we would find it interesting to create a world with intelligent beings in it, and that there is a chance, maybe not that high, but still greater than zero, that this would also be the case for the Designer. Given how unlikely it is that we live in a non-designed universe, this may be a fairly attractive option.

However, let us try an approach based on the same principles used everywhere else in this paper. This argument will have the following structure:

- The probability that a universe designed for intelligent beings has a finite description is non-zero.
- There is a good chance that a Designer would not design two things that are too similar.
- The set of similarity thresholds that are relevant for this paper is countable.
- Given the above, there is a good chance that the set of things that are designed (called purposes) is at most countable.
- There is a good (non-zero) chance that, for a similarity threshold which is high enough, any purpose which is "too similar" to the purpose where the Designer wants intelligent beings for their own sake, also involves intelligent beings.
- Combining all the above, there is a non-zero chance that a designer would want to design a world at least in part for the intelligent beings that would live in it.

Let us start with what we want to estimate: how large is the probability of having a large consistent time-space region when a Designer is involved?

We can separate this probability in two: the probability that a Designer would want rational beings[8], denoted by p_r, and the probability that the universe region containing those intelligent beings is consistent given that it was designed for them.

[8]A Designer could want a consistent universe region with a finite description without wanting intelligent beings, but this possibility is not analyzed in this paper.

I think it's safe to assume that the latter probability is positive, and, probably, fairly high. See as an example the following quote from R. G. Swinburne (2003), which argues that, if God exists, there is a fairly good chance that humans can understand their universe. The same argument can be applied to show that, if a Designer wanted rational beings, a large region of the universe around them is understandable (perhaps the entire universe), i.e. that region probably has a finite description.

> So, in order to have significant freedom and responsibility, humans need at any time to be situated in a "space" in which there is a region of basic control and perception, and a wider region into which we can extend our perception and control by learning which of our basic actions and perceptions have which more distant effects and causes when we are stationary, and by learning which of our basic actions cause movement into which part of the wider region. If we are to learn which of our basic actions done where have which more distant effects (including which ones move us into which parts of the wider region), and which distant events will have which basically perceptible effects, the spatial world must be governed by laws of nature. For only if there are such regularities will there be recipes for changing things and recipes for extending knowledge that creatures can learn and utilize. So humans need a spatial location in a law governed universe in which to exercise their capacities, and so there is an argument from our being thus situated to God.

Next, let us note that the design and non-design cases have some differences.

One such difference is that, for an intelligent Designer/Creator, what is being created corresponds, one way or another, to a purpose. To be consistent with the approach used in this paper, let us assume that the set of possible purposes has at most the cardinality of real numbers, $\mathbb{R}$. Certainly, the set of purposes that could be described in words, even if we use an infinite number of words, has this cardinality.

There could be a number of universes with distinct descriptions for each purpose, but, since intelligence and design imply choice, we should not expect that each possible purpose is an actual purpose. It is reasonable to assume that, for each actual purpose, there were many similar purposes that were discarded when the actual one was chosen.

If that is the case, we could ask ourselves two things: how large is the set of actual purposes, i.e. whether it is at most countable, and whether one of the actual purposes involves creating intelligent beings.

I think it is hard to estimate the likelihood of any of these, but, for the purpose of this paper, it is probably good enough to show that, by default, we should assign a non-zero probability to both.

First, let us note that, for real numbers, the similarity of two numbers is, most often, linked to the distance between them (usually the similarity is the inverse of the distance). Also, if we want to pick a subset of real numbers such that no two of them are closer than a given distance (i.e. no two numbers are too similar), then that subset is at most countable.

It is not obvious that similarity between purposes works in the same way as similarity between real numbers, but I think there is a non-zero chance that if the Designer does not choose purposes which are too similar, then the set of chosen purposes is at most countable. Arguably, that chance is fairly high. In the following we will implicitly focus only on the case when choosing non-similar purposes means that their set is at most countable.

Given a countable set of purposes, we can (and should) assign by default a non-zero probability to all of them.

We do not know what purposes would be in this set. However, we can cover all the interesting cases by taking all maximal sets of purposes that are not too similar (maximal meaning that we can not add any other purpose to it without breaking the similarity constraint), and we can ask ourselves whether one of these purposes would involve creating rational beings.

To do that, let us take a closer look at the similarity threshold. For any such threshold t, there will be a natural number n such that the similarity threshold is between $1/n$ (exclusive) and $1/(n+1)$ (inclusive). Since the set of purposes that were chosen by the Designer using t as a threshold can also be chosen using $1/(n+1)$ as a threshold, in the following we will use only thresholds derived from natural numbers.

Since the new set of possible similarity thresholds is countable, we should assign a non-zero probability to each of them.

There is a possible purpose where the designer wants intelligent beings for their own sake, which I will call "the main intelligent beings purpose". Given a similarity threshold high enough, there is a good chance that any purpose whose similarity to the main intelligent beings purpose is above that threshold will also involve intelligent beings.

Given any maximal set of purposes that are not too similar, at least one of them (called P) will be "too similar" to the main intelligent beings purpose. As mentioned above, if the similarity threshold is high enough, then there is a good chance that everything in P involves intelligent beings.

So far, we have a non-zero probability that the set of buckets is countable, a non-zero chance of choosing a purpose from the bucket with the main intelligent beings purpose, a non-zero chance that below a threshold $1/n$ this bucket contains only purposes involving intelligent beings, and a non-zero chance that the actual threshold that we should use is below $1/n$. Then we have a non-zero overall chance of having a universe designed for intelligent beings.

Virgil

5. TODO: Use Swinburne's argument about why would God create human-like beings.

7 Objections and Clarifications

This section includes various possible objections to this argument. Since the fine-tuning argument addresses the same problem, and it's also using a probabilistic argument (though in a completely different way), some of the objections below are similar to the fine-tuning ones, and it may be helpful to compare the two approaches.

For the fine-tuning argument see, e.g., (Friederich, 2018). For objections to the fine-tuning argument that are relevant here, see, e.g., (Manson & Thrush, 2003; Manson, 2009; McGrew, McGrew, & Vestrup, 2001; Narveson, 2003;

Virgil

Second, a good question is whether, in a designed world, intelligent beings would be able to identify this design by looking

Sober, 2009). For possible answers see, e.g. Leslie (2003), R. G. Swinburne (2003), Monton (2006), Kotzen (2012).

7.1 Observation Selection Effect and Multiple Universes

In this paper, we only look at universes that contain intelligent life, and that restricts the set of possible universe descriptions. Even more, we don't see a universe as it is, instead we see it through the eyes of the intelligent beings inhabiting it. It can be argued that, in a non-created universe, beings might be intelligent only if their intelligence is useful to them. But this likely means that those beings live in a timespace region which seems consistent from their point of view, so maybe it's not that unlikely to see consistency around us.

However, let us look more carefully at how much consistency we would expect. There are possible universes with consistent regions in which intelligent life can exist, and whose consistency ends abruptly at some random time. There are possible universes whose consistent regions are strictly the size needed for allowing intelligent life, and there are possible universes with large consistent regions.

Let us assume that our existence means that some consistency is required. Is there any non-required consistency around us, consistency which is due to chance? To be more precise, how large is the time-space region whose consistency is required? Well, perhaps at very distant times in the past, the consistent region included the entire observable universe, but, right now, there is no reason to require full consistency outside of, say, Earth's orbit. Even more, it's likely that we don't even need full consistency inside of Earth's orbit.

However, as far as we know, our solar system is consistent, our galaxy is fairly consistent, and distant galaxies are also fairly consistent.

This paper argues that, since we do observe much more consistency than we would expect, design is the right explanation.

However, there is a possible objection related to this: if multiple universes exist, perhaps all possible ones, there will be some beings living in the implausibly consistent ones.

While this is correct, the probability of an intelligent being living in a fully consistent universe is still 0. In almost all universes the nonhomogeneity of the universe would be easily observable, meaning that, for the relatively few intelligent beings living in the other universes, as long as the design hypothesis has some plausibility, it would be unreasonable to think that their universe is not designed (assuming that the argument presented in this paper is correct).

7.2 Few Universes Exist

Another possible objection is: we used a meta-universe definition that's too restrictive. What would happen if, say, we had a meta-universe that, instead of providing a probability distribution over universes, simply restricts the possible universe descriptions to a given set?

We have these options: the set is countable, the set has the same cardinality as $\mathbb{R}$, and, if we reject the continuum hypothesis[9], the set can be somewhere between the two.

[9] The continuum hypothesis states that there is no set whose cardinality is strictly between that of the natural numbers and the real numbers.

If the set is countable, then let us note that, by observing this meta-universe, we are actually observing a countable set of elements chosen from the full set of universe descriptions, so, by default, all of them should be generic. If not, we can repeat the same argument as above to show that either we have an uncountable chain of improbable meta-universes, or these descriptions should be generic.

If the set has the same cardinality as $\mathbb{R}$, then we observe an element of this set, our universe's description, and there is no probability distribution describing how to pick a description, so, according to axiom 2, it should be generic.

If the set is not countable, but its cardinality is less than $\mathbb{R}$, then let us note that this paper's axioms should still be valid when using this cardinality instead of $\mathbb{R}$. As an example, the set of discontinuities would still be at most countable, and, by default, we should use continuous probability distributions, and if we observe any element with probability 0, it should be generic.

To be specific, if we replace the set of real numbers by a set whose cardinality is above countable, but at most that of the real numbers in axioms 1, 2 and 4, the argument should still work.

We should be able to get the same results when working with approximations: if, instead of looking at the set of all distinct descriptions, we take a level of approximation L and we group descriptions that, given L, work for the same universes. As argued in section 7.3, there are $\mathbb{R}$ conceivable descriptions which are different enough, so each of these would be in a different group, which means that there are $\mathbb{R}$ groups of conceivable descriptions. Using the same reasoning as above, with probability 1, the set of groups of conceivable descriptions which are possible according to the meta-universe rules has the same cardinality as $\mathbb{R}$. From these groups, we can extract a similar cardinal of possible descriptions, which should be different enough since we grouped them based on similarity.

7.3 Not Enough Descriptions

When working without approximations, there are $\mathbb{R}$ possible descriptions that are essentially different. However, this is less obvious when working with approximations, especially since that means we can probably have incompatible descriptions for the same universe.

Let us assume (as an axiom) that, for a given level of approximation L, we can find a finite cuboid size for which there is a finite set of (full-precision) descriptions, let us call it D_f, which cannot all be approximated with a single finite approximate description. In other words, if we have a set of cuboids whose descriptions include the D_f set, we can't find a single finite approximate description that works for all of them within the level of approximation L.

In the following, the difference between cuboid descriptions and universe descriptions is not always explicit, but can be inferred from the context.

Here is an incomplete example that shows why the above axiom is reasonable. First, let us assume that we have a set of "primary measurements" that we can do for our model, such that any other measurement that we could do can be computed from those. Then let us take two descriptions, the first saying "the value of each primary measurement is 0", and the second saying "the value of each primary measurement oscillates quickly between 0 and something large enough to be easily detected within the approximation level".

Then, let us consider a hypothetical infinite universe with an n-dimensional timespace based on the real numbers. Let us divide it in cuboids of the size mentioned above and let us assign the incompatible descriptions in the set mentioned above to these cuboids in a roughly even way. The set of cuboids is countable, so there are $\mathbb{R}$ ways of assigning these descriptions.

Let us pick an assignment and let us pick a timespace point very close to the time end of a space-time cuboid boundary. Let us take that entire point's past and let us try to make a prediction based on that. First, based on just that past, we can't predict the type of the next cuboid, since there will be many possible assignments that have the same past, but in which the next cuboid will be different from the current assignment.

Still, a universe description must predict the future from the past, and the future depends only on the next cuboid type. Then, the universe description must allow predicting the next cuboid type, so it must include, implicitly or explicitly, a function predicting the next cuboid from a cuboid's past and its context (i.e. position). Now we must find out how many such functions we need in order to describe all possible assignments.

To make things simpler, let us assume that the number of dimensions, n, is 1 (i.e. we have only events ordered by time - a group of such events taking place between two moments in time would be a time-space cuboid; we could also consider the case when the space contains only one space-cuboid, and the time dimension is infinite - a time-space cuboid would consist of the space cuboid taken for a given time interval) and that we have only two cuboid types. It should be obvious that the remainder of this example can be generalized to any number of dimensions and to any number of cuboid types greater than 2.

Having $n = 1$, means that we have a one-to-one correspondence between integers and cuboids, so let us identify a cuboid with its number through this correspondence. Let us also denote the two cuboid types by 0 and 1 and let us represent a universe as a function from the set of integers (representing the set of cuboids), $\mathbb{Z}$, to the set $\{0, 1\}$, identifying, for each cuboid, its type.

We can represent the information available for predicting the type of a future cuboid by a pair between the cuboid and its past, let us denote it by (x, p_x) where x is the cuboid's number, 0 or 1, and p_x, which represents x's past, is a function from the set of natural numbers to $\{0, 1\}$.

However, we are not trying to predict just one cuboid's future, we are trying to predict the future of all cuboids. Any way of making these predictions can be put in a 1:1 correspondence with a function from the past of cuboids to their future, i.e. from (x, p_x) pairs to $\{0, 1\}$.

Let us find out how many distinct functions we need. To make things simple, let us consider only universes which, for negative integers, have only cuboids of type 0.

The past of cuboid 0 is perfectly identical in all these universes, so, in order to predict the type of the cuboid with index 0, we need two distinct prediction functions: one which predicts that the type is 0, another one that predicts that the type is 1. In order to predict the types of the first two cuboids, 0 and 1, we need four distinct prediction functions. In general, in order to predict the types of all cuboids between 0 and n we need 2^{n+1} distinct prediction functions. And, in order to predict the type of all cuboids which are greater or equal to 0, we need $2^{\mathbb{N}}$, i.e. the power set of the natural numbers, i.e. $\mathbb{R}$ prediction functions.

As mentioned previously, intelligent beings may need some consistent space-time around them. Even if that's the case, fixing the cuboid type for a finite chunk of an infinite universe does not change the cardinal for the set of functions mentioned above.

7.4 Multiple Universes Based on the Same Laws

As mentioned above, our universe could be included in a meta-universe in which, colloquially speaking, all universes have the same laws, but different fundamental constants, and no other universes are allowed. Of course, using this paper's definitions, the fundamental constants would be part of a universe's description.

When using approximate universe descriptions, since our universe seems to be based on laws that are continuous in these fundamental constants, the set constants that are "different enough" should be at most countable.

Since no other universe is allowed, and the set of allowed approximate descriptions is countable, the meta-universe's probability has to be non-zero for some of these descriptions. In other words, the meta-universe probability has some peculiar discontinuities, which, as mentioned above, is implausible.

7.5 Complicated universe

Above we have argued that we can divide the universe region around us in small identical pieces, all of which have finite approximate descriptions, and that any description that works for one of them works for all of them.

Of course, in practice, we can only work with finite descriptions when modelling our universe. Fortunately, quantum mechanics, together with relativity (although they may be incompatible), form a finite description which seems to fit our universe almost perfectly. Even Newtonian physics seems to be pretty good.

However, we can ask ourselves whether our timespace region is actually much more complex, perhaps infinitely complex, but we didn't manage to notice that yet.

This is possible, but the main part of this paper's argument can be applied here: We do notice a lot of consistency in the timespace around us, perhaps because we do not (or can not) pay attention to enough aspects of the universe. At the same time, it is conceivable that the time-space that we observe is not consistent in this way. This means that, if we divide our timespace in regions and we fix a reference one, it is unreasonable to have a probability of 1 that any other region is consistent with the reference, at least in the aspects to which we pay attention.

But, in a similar way to section 6.3, this means that we are observing something having a really low probability, and that it's more reasonable to think that our universe is designed.

8 Conclusion

We have the following reasonable possibilities:

1. The probability that a Designer would want intelligent beings is non-zero (see section 6.4), our universe is designed (at least in part) for us, and the

universe around us is, roughly, as homogenous as we would expect it to be.

2. Section 6.4 does not make sense, we don't know whether our universe is designed or not, our universe is not homogenous, but we observe some extremely unlikely homogeneity around us.

The most reasonable option seems to be that our universe is designed.

9 Mathematical Background

This section presents the mathematical results used in this paper. They are usually presented without proofs, but most introductory courses on the topic of each subsection should cover them.

This section also contains precise definitions for some of the concepts that are specific to this paper (namely "generic" and "peculiar").

9.1 Probabilities

For the following definitions, see Billingsley (1995) (section "Probability Measures").

A probability measure P is a function defined on some of the subsets of a space Ω. P should satisfy three conditions:

- $0 \leq P(A) \leq P(\Omega)$ for all A for which P is defined;
- $P(\emptyset) = 0$ and $P(\Omega) = 0$;
- If $A_1, A_2, \ldots$ is a disjoint sequence of sets for which P is defined, then P is defined for their union, and $P(\bigcup\limits_{i=1}^{\infty} A_i) = \sum_{i=1}^{\infty} P(A_i)$

The subsets for which P is defined are called "events".

A probability P is continuous if it assigns 0 to each single element set (this is a generalization of the "absolutely continuous" property used in Billingsley (1995)). As an example, both the uniform probability for a real number interval and the normal probability over the set of real numbers are continuous.

Any single element set for which the probability assigns a non-zero value is called a discontinuity.

The terms "probability measure" and "probability distribution" will be used interchangeably.

9.1.1 Peculiar and generic events

Let A be a set with the same cardinality as the set of real numbers, $\mathbb{R}$, with a probability distribution P. Let F be the set of all mathematical predicates of one variable over A that can be written as a finite formula. If f is such a predicate then let A_f be the subset of A where f is true, i.e. $A_f = \{a \in A \mid f(a) \text{ is true}\}$. Whenever $P(A_f)$ is defined, we will also denote it by $P(f)$, and we will call it "the probability of f".

Let F_0 be the set of predicates in F whose probability is 0 for all continuous probability distributions over A, i.e.

$$F_0 = \{f \in F \mid P(A_f) = 0 \text{ for all continuous probability distributions over } A\}\,.$$

As an example, any predicate f which is true for a finite subset of elements, i.e. A_f is finite, and would belong to F_0.

Let us identify by A_0 the set of elements of A for which at least one predicate of F_0 is true, i.e.

$$A_0 = \{a \in A \mid \exists f \in F_0 \text{ with } f(a) \text{ true}\}\,.$$

Let us also denote A_1 the complement of A_0.

In the following, let us assume that P is a continuous probability distribution.

Since F, the set of all predicates, is countable, F_0 must be at most countable. This means that A_0 is an at most countable union of sets, one set for each element of F_0, i.e. $A_0 = \cup_{f \in F_0} A_f$. This means that $P(A_0)$ is less or equal to the sum of the probabilities of these sets, $P(A_0) \leq \sum_{f \in F_0} P(A_f)$. Since this sum is 0, then $P(A_0)$ is 0. This means that $P(A_1) = 1$.

Let us say that an element $a \in A_1$ is **generic** and an element $a \in A_0$ is **peculiar**. Then we could rewrite the equalities above to $P(x \text{ is generic}) = 1$ and $P(x \text{ is peculiar}) = 0$.

When the probability for a subset of A is 0, $P(E) = 0$, where $E \subset A$, it does not mean that observing an element of E is logically impossible, it means that, if we make a set of (independent) observations of elements of A that is at most countable, we have no chance at all of observing an element of E.

9.1.2 Countable discontinuities

Let us now consider a different issue. Let P be a probability over the set of real numbers, $\mathbb{R}$ (or any infinite uncountable set). Let A be the set of real numbers with non-zero probability. Then A is at most countable, see Billingsley (1995) (page 162, Theorem 10.2).

9.2 Ordinals

For the definitions and properties presented in this section, see Bagaria (2020) and Cohen (1966).

Ordinals are generalizations of natural numbers. Natural numbers can be defined by identifying each natural number with the set of natural numbers less than it. Then 0 is identified with the empty set $\emptyset$, 1 with $\{0\} = \{\emptyset\}$, 2 with $\{0, 1\} = \{\emptyset, \{\emptyset\}\}$, and so on.

Each of the natural numbers defined as above is an ordinal. However, we can define ordinals that do not correspond to natural numbers. The smallest such ordinal, denoted by ω, is defined with the same rule: let ω be the set of ordinals smaller than it, i.e the set of natural numbers, $\omega = \{0, 1, 2, \ldots\}$.

Of course, the next ordinal, called $\omega + 1$, will be the set $\{0, 1, 2, \ldots \omega\}$ and the next one, $\omega + 2$, will be $\{0, 1, 2, \ldots \omega, \omega + 1\}$. We can continue and, in the same way, define $\omega \cdot 2 = \omega + \omega$ to be the ordinal that comes after all ordinals of the form $\omega + n$ where n is a finite ordinal (i.e a natural number).

Then we can define $\omega \cdot 3$, $\omega \cdot 4$ and so on, and we can take $\omega \cdot \omega$ to be the ordinal that comes after all the ones defined by using the above rules.

Let us note that ω is countable, and that all the ordinals mentioned above that come after it are also countable. By using the same kind of reasoning as above we can produce other countable ordinals like ω^ω (containing ordinals like $\omega \cdot \omega \cdot \dots \cdot \omega$) and ϵ_0 (containing $\omega^{\omega^{\cdot^{\cdot^{\cdot^{\omega}}}}}$).

After going through many similar processes, at some point we obtain the smallest uncountable ordinal, ω_1, which is the set of all countable ordinals.

Let us note that some ordinals, like all the finite ones except 0, and like $\omega + 1$, can be obtained from the previous one by using a successor relation, i.e. $successor(\alpha) = \alpha \cup \{\alpha\}$. All ordinals have a successor, but not all are successors, some, like ω and $\omega \cdot 2$ can be defined only as the set of all smaller ordinals. The former are called “successor ordinals”, the later are called “limit ordinals”. Note that 0 is a limit ordinal.

9.3 Cardinals

The set of natural numbers $\mathbb{N}$, the set of integers $\mathbb{Z}$ and the set of rational numbers $\mathbb{Q}$ are countable.

The set of real numbers $\mathbb{R}$ has a larger cardinality, the same cardinality as the power set of a countable set. Another way to put this is that if we have a countable set, and, for each element, we can choose one of two options, and we take all ways of choosing options for the entire countable set, then we get a set with the same cardinal as the set of real numbers[10]. That is, the set of all functions

$$f : \mathbb{N} \longrightarrow \{1, 2\}$$

has the same cardinality as $\mathbb{R}$.

If we have a set with the same cardinality as the set of real numbers, and we remove a countable set, the resulting set still has the same cardinality as the set of real numbers. As an example, $\mathbb{R}$, $\mathbb{R} \setminus \mathbb{N}$, $\mathbb{R} \setminus \mathbb{Z}$ and $\mathbb{R} \setminus \mathbb{Q}$ all have the same cardinality. In general, if A and B are infinite sets and B's cardinality is lower than A, then removing B from A does not change its cardinal, i.e. $A \setminus B$ has the same cardinal as A.

If A has an infinite cardinal, then the product set $A \times A$ has the same cardinality as A.

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[10] This is also valid for more than two options, as long as the cardinality of their set is at most countable.

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