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DOES FINE-TUNING NEED AN EXPLANATION?

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Abstract

Contemporary physics has shown that the universe is fine-tuned for life i.e. of all the possible ways physical laws, initial conditions and constants of physics could have been configured, only an extremely small range is capable of supporting life. Some theists have argued that fine-tuning can be used as a premise in a design argument for the existence of God, while some other scientists and philosophers have argued that fine-tuning provides an evidence for a multiverse, a hypothesis which claim that there is more than one universe. Both approaches assume that fine-tuning require some kind of explanation. Despite the initial appeal some philosophers and scientists have denied the need of explanation for the fine-tuning. They either deny that the universe is fine-tuned for existence or else think that we should not be surprised that universe is fine-tuned, and therefore should not search for explanation. In this paper we analyse some of these claims and try to show that neither of them succeeds in demonstrating that fine-tuning does not need an explanation.

Keywords: Philosophy of Religion, Fine-tuning, Teleological Argument, Multiverse, Arguments for Theism, Naturalism.

HASSAS AYAR AÇIKLAMAYA MUHTAÇ MIDIR?

Öz

Çağdaş fizik evrenimizin yaşam için hassas ayarlı olduğunu göstermiştir. Evrenin yaşam için hassas ayarlı olması demek fizik yasaları, başlangıç koşulları ve temel fizik sabitlerinin alabileceği muhtemel değerlerden çok azı yaşama izin vermesi demektir. Bazı teist düşünürler hassas ayarın Tanrı'nın varlığı lehinde geliştirilebilecek Tasarım kanıtlarında öncül görevi görebileceğini iddia etmişlerdir. Diğer taraftan bazı felsefeci ve bilim insanları hassas ayar gözlemenin birden fazla evrenin var olduğunu savunan çok evrenler hipotezini desteklediğini iddia etmişlerdir. Bu iki yaklaşım da hassas ayarın bir açıklamaya muhtaç olduğunu varsayımını yapar. İlk bakışta bu varsayım makul gözükse de bazı felsefeci ve bilim insanları hassas ayarın bir açıklamaya muhtaç olduğu iddiasını reddetmişlerdir. Bu yaklaşımı savunanlar ya evrenin yaşam için hassas ayarlı olmadığını ya da evrenin hassas ayarlı olmasına şaşırmamamız gerektiğini, dolayısı ile hassas ayarın bir açıklamaya ihtiyaç duymadığını iddia etmişlerdir. Bu makalemizde bu iddialarının bir kısmını ele alarak değerlendirecek ve hassas ayarın açıklamaya muhtaç olmadığını temellendirmede başarısız olduklarını göstermeye çalışacağız.

Anahtar Kelimeler: Din Felsefesi, Hassas Ayar, Teleolojik Kanıt, Çok-Evrenler, Teizm Lehindeki Argümanlar, Doğalcılık.

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1. Introduction

Teleological or design arguments are form of argument which seek to demonstrate the existence of Grand Designer i.e. God based on some feature of the universe which seems to exhibit purpose or order. Teleological argument is one of the classic argument forms for the existence of God, and has been defended by many prominent thinkers such as Platon, Stoics, Ghazali, Ibn Rushd, Thomas Aquinas, Newton, Leibnitz; and criticized by Lucretius, Hume, Kant, Soren Kierkegaard. This argument was especially popular in Muslim thinking, since it seems to be suggested by many passages in Quran. Therefore Ibn Rushd named the argument "Quranic argument" (the arguments from *inaya* and *ikhtira*).

After the criticisms of Hume and Kant and rise of positivist critique of metaphysics the teleological argument lost its popularity. However, after 1970s the argument made a comeback in a new form. Physicists recognized that the universe seems to be extremely fine-tuned for the emergence of life. This new argument is not based in analogy and is formulable rigorously in Bayesian or abductive forms. In this paper we will analyse an abductive form of teleological argument, based upon examples of fine-tuning. After briefly reviewing the fine-tuning of the universe for life and the argument based on it, we defend the argument against the objections which deny the need for explanation of the fine-tuning.

This article does not reflect an insufficiency in terms of meeting the standards of this journal to a certain degree. On that note its main argument is clearly stated at the beginning and the positions of some physicists are very well-exposed. However, the reader needs to be sign-posted about the flow of the argument. In particular, the reasoning behind the selection of these 6 objections to the fine-tuning arguments needs to be made clear. The reason why the author chose these particular six objections is not clearly stated and also the reason why some other arguments are ignored is not contextualized. This is a major drawback since Derek Parfit's article titled "Why Anything? Why This?" seems to be quite relevant to the argumentation demonstrated in this article. The author needs to consider the arguments provided by Derek Parfit within the context of the need to explain fine-tuning. In this regard, the contemporary physicists' observations with regards to the possible worlds, also, need to be addressed. Another minor point is that at times the arguments are not clearly exposed to the reader: for instance "Hospitable universes are special not only because they support life, but also because they alone exhibit attributes such as morality, aesthetics, consciousness etc. Thus it seems that fine-tuning requires an explanation beyond pure chance". Another place the sense of argumentation needs to be made clear is the following: "Criteria 5 is also insufficient: the maximum mass of the star should be greater than the minimum mass of the star. And Criteria 2, 3 and 5 are wrong - and of course many crucial criteria are missing". If, and only if, the author tackles these issues, I would recommend publishing this article in the journal.

2. The Fine-Tuning of the Universe for Life

A universe capable of sustaining life must be able to support beings which are able to reproduce and to store and use energy. These are necessary but not sufficient conditions for the emergence of intelligent life. Such conditions can only be provided by a universe exhibiting stable energy sources and a rich chemistry capable of yielding molecular structures, reproduction and the storage of energy. In the 1970's - after classic papers by Carter[1], Carr and Rees[2], Paul Davies[3]and the extensive study of Barrow and Tipler[4]- physicists realized that the set of possible laws, constants and initial conditions of the universe conducive to the emergence of stable energy sources (stars) as well as chemistry, and therefore life, is extremely small. This was termed the 'fine-tuning' of the universe for life. Since 1970's the examples of fine-tuning increased extensively[5], and physicists and philosophers have sought to account for - or questioned whether we need account for – fine-tuning. Our aim in this paper is to assess whether fine-tuning requires an explanation

Examples of fine-tuning can be categorised three-fold:

1. The fine-tuning of the laws of nature.
2. The fine-tuning of the fundamental physical constants.
3. The fine-tuning of the initial conditions of the universe.

In the next subsections we will provide several examples from each of these categories.

2.1. The fine-tuning of the laws of nature

The first category of examples of fine-tuning are due to the laws of nature. Were the fundamental laws governing the universe different, the universe probably would have been sterile. To illustrate, let's take the two of the four fundamental forces:

Electromagnetic Force: Electromagnetic Force is a long-range force between charged objects. It is attractive for opposing and repulsive for the like charges. Mathematically it has a similar structure to gravitational force: $F = kqQ/r^2$, where$F$ denotes the electromagnetic force, q and Q are charge magnitudes, k is a

1 B. Carter, "Confrontations of Cosmological Theories with Observational Data", *IAU Symposium, Vol. 63*, ed. M.S. Longair M. S. D. (Reidel:Dordrecht, 1974): 291-298.

2 B. Carr and M. Rees, "The anthropic principle and the structure of the physical World", *Nature*, 278, (1979): 605-612.

3 P. Davies, "The anthropic principle", *Prog. Part. Nucl. Phys.*, 10, (1989): 1 – 38.

4 J.D. Barrow and F.J., Tipler, *The Antropic Cosmological Principle*, (Oxford: Clarendon Press, 1986).

5 For technical reviews of the progress in the field, the reader may consult: J. Hogan, "Why the universe is just so", *Reviews of Modern Physics*, 72-4, (2000):1149-1161; L. Barnes, "Fine-tuning of the universe for life", *Publications of the Astronomical Society of Australia*, 29-4, (2013): 529-564. For popular level presentations see: M. Rees, *Just Six Numbers: The Deep Forces that Shape the Universe*, (London: Weidenfeld & Nicolson, 1999); P. Davies, *The Goldilocks Enigma*, (Houghton: Mifflin Harcourt, 2007).

constant determining the strength of the force, and r is the distance between the charges. It is the force which holds negatively charged electrons around a positively charged nucleus. Thus, were there no electromagnetic force, or were it attractive for like charges, and repulsive for opposing charges, the formation of atoms would have been precluded. Thereby, we would have neither chemistry nor stable energy sources, and life would subsequently not have been possible.

Strong Nuclear Force: Strong Nuclear Force is a short-range force that holds together the positively charged protons and neutral neutrons in the nucleus of an atom. Were there no strong force, or were it repulsive or weaker than the electromagnetic force, no atom but for Hydrogen would have formed. Consequently, no life would have been possible. On the other hand, were it long-range (like gravity or the electromagnetic force) atoms would again not have formed, as such would have instead resulted in large, spherical and uniform structures.

The fine-tuning of the laws of nature is not limited to the two fundamental forces discussed above. Other two are important as well, without gravity stars would not have formed, without weak nuclear force stars would not be able to form the heavy elements necessary for the rich chemistry. If Pauli exclusion principle did not exist, we would not have a stable atom and hence no chemistry. These are just representative examples.

2.2. The fine tuning of the fundamental physical constants

Even assuming our actual laws of nature, such laws do not guarantee the emergence of life. Besides the laws, fundamental physical constants must also fall within a narrow range of values. Here is Stephen Hawking and Leonard Mlodinow's explanations of the fine-tuning of the fundamental physical constants:

> Most of the fundamental constants in our theories appear fine-tuned in the sense that if they were altered by only modest amounts, the universe would be qualitatively different, and in many cases unsuitable for the development of life. . . . The emergence of the complex structures capable of supporting intelligent observers seems to be very fragile. The laws of nature form a system that is extremely fine-tuned, and very little in physical law can be altered without destroying the possibility of the development of life as we know it. Were it not for a series of startling coincidences in the precise details of physical law, it seems, humans and similar life-forms would never have come into being.[6]

Let us provide some examples of the fine-tuning of the fundamental physical constants.

The cosmological constant (Λ): This term arises from Einstein's equation of general relativity and regulates the expansion rate of the universe. If it has a positive value, it acts as a repulsive force yielding the expansion of space; if negative, it acts as an attractive force contracting space. Quantum Field Theoretical predictions are 10^{120} times greater than the observed value - undoubtedly the

[6] S. Hawking and L. Mlodinow, *The Grand Design*, (New York: Bantam Books, 2010): 160-161.

greatest estimation error in physics. Hence, there must be some cancellation mechanism which matches with the quantum vacuum term in the first 120 decimal places, as explained by Weinberg:

> There may be a cosmological constant in the field equations whose value just cancels the effects of the vacuum mass density produced by quantum fluctuations. But to avoid conflict with astronomical observation, this cancellation would have to be accurate to at least 120 decimal places. Why in the world should the cosmological constant be so precisely fine-tuned?[7]

If this cancellation mechanism matched one less decimal place with the effects of vacuum mass density, it would preclude life.[8] As demonstrated by Weinberg, even a small increase in the cosmological constant would inhibit the formation of galaxies, and hence stars.[9] On the other hand, were it smaller, the universe would have collapsed prior to the possible emergence of life.

The Dimensionality of the universe (D): Our universe has three observable[10] spatial and one temporal dimension. This is the only combination capable of sustaining life. Had there been an additional temporal dimension no massive particle would have been stable[11], and chemistry would thus have been impossible. Similarly, a difference in the number of spatial dimensions would have yielded the instability of atoms and planets[12], rendering life impossible.[13]

2.3. The fine tuning of the initial conditions of the universe

The fate of the universe is not only determined by the laws of nature and the fundamental constants, but is also sensitive to its initial boundary conditions. And it tuns out that initial and boundary conditions also appear to be fine-tuned. Here is an example:

The amplitude of primordial fluctuations (Q): This is the energy required to break up and disperse an instance of the largest structures - i.e. galactic clusters - expressed as a fraction of the rest mass energy of that structure. It is a dimensionless constant with the value$Q \approx 10^{-5}$. Were it smaller than 10^{-6}, gas would never condense into gravitationally bound structures, thereby inhibiting the formation of stars. On the other hand, were it greater than 10^{-5}, the universe

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7 S. Weinberg, *The first three minutes: a modern view of the origin of the universe*, (New York: Basic Books, 1977): 186-187.

8 P. Davies, *The Goldilocks Enigma*, 166-170

9 S. Weinberg, "Anthropic Bound on the Cosmological Constant", *Physical Review Letter*, 59, (1987): 2607.

10 There may be unobservable small spatial dimensions as predicted by string theory. But presence of unobservable dimensions does not effect our argument, what matter is the number of dimensions felt by atoms. And even in string theory date number must be three as it is an experimental fact.

11 J. Dorling, "Dimensionality of time", *American Journal of Physics*, 38 (1970): 539.

12 P. Ehrenfest, "Can atoms or planets exist in higher dimensions?", *Proceedings of the Amsterdam Academy*, 20 (1917): 200-203.

13 For more careful analysis of fine tuning of dimensionality of space-time reader may want to consult: M. Tegmark, "On the Dimensionality of Spacetime", *Classical and Quantum Gravity*, 14, (1997): L69-L75.

would be turbulent and violent: in the early universe structures greater than galaxies would have formed which would not have fragmented into stars, but rather would have created giant black holes greater than clusters of galaxies.[14]Life would have been impossible in either scenario.[15]

We should not that this is not the sole example of the fine-tuning of the initial conditions. Other examples such as initial entropy of the universe (S) can be provided.

3. Fine Tuning as an Evidence for Theism

The examples of fine-tuning outlined prompt the questions of whether they require explanation, and of what such an explanation may be. If one can show that fine-tuning requires explanation, and that theism provides a comparably superior explanation than its alternatives, then we will have an inference to the best explanation type of argument in favour of theism. Such argument can be expressed in premises as:

1. The fine-tuning of the universe requires explanation.
2. There is a theistic explanation: that God designed the universe for the emergence of life.
3. There is no comparably satisfying non-theistic explanation of why universe is fine-tuned.
4. Therefore, the fine-tuning of the universe provides evidential support for theism.

In this article we will concentrate on the first premise. The first premise initially seems very compelling. Given that an extremely small subset of possible configurations of physical laws, constants and initial conditions permits life, our universe's membership of that subset seems very surprising. Nearly all the physicists and philosophers who are aware of the fine-tuning of the universe agree that this peculiar fact requires some kind of explanation. The *prima facie* need for explanation inheres in the magnitude of the improbabilities. As explained above, for example, the cosmological constant must be set to precision of 1 in 10^{120}. Let us try to imagine how small this number is. In one centimeter there are 100 million of atoms, end every atom is composed of electrons, protons and neutrons. And there are billions, billons of stars in each galaxy. And our universe contains more than hundred billions of galaxies. Given these you can imagine how many particles are there in the universe. Therefore choosing one particular particle of this universe

14 M. Rees, *Just Six Numbers: The Deep Forces that Shape the Universe*, 115.

15 For more technical and careful analysis of the fine-tuning of the amplitude of primordial fluctuations look at: M. Tegmark and M. Rees, "Why Is the Cosmic Microwave Background Fluctuation Level 10–5?", *The Astrophysical Journal*, 499, (1998): 526.; M. Tegmark, A. Aguirre, M. Rees, F. Wilczek, "Dimensionless constants, cosmology, and other dark matters", *Physical Review D*, 73, (2006): 023505.

and getting it by chance alone seems impossible. But the probability of choosing some particular particle by chance is billions and billions of times higher than the probability of 1 in 10^{120}. Given the improbability of even choosing one hidden particular grain of sand in a dessert randomly, we believe that reader can easily grasp how improbable 1 in 10^{120}. And this is one among many fine-tuned parameters and laws. If the chance of having these parameters was, for example 1 in 10, instead of probabilities like1 in 10^{120} , one could say that it does not require any explanation and probably nobody would make any design inference , but simply the odds are too much to ignore.

Despite the initial appeal some philosophers and scientists have denied the need of explanation for the fine-tuning. They either deny that the universe is fine-tuned for existence or else think that we should not be surprised that universe is fine-tuned, and therefore should not search for explanation. Let us evaluate each of these claims.

4. Pure Chance

One frequent response is to deny the need for explanation by pointing to the fact that any other individual possible universe is equally as unlikely as our own. According to this approach, given that other possible values of constants are as unlikely as our own, we need not search for any additional explanation besides chance[16]. Consider the following analogy: suppose that Emre wins a lottery in which ten million people participle. Certainly, Emre's winning the lottery is a very low probability event, but since any other person's chance of winning the lottery is of as equally low probability as Emre's, we need not search for any special explanation of his win. Pure chance is enough to explain Emre's winning the lottery. Similarly, this response continues, the fine-tuning of our universe may be considered the result of a cosmic lottery which similarly can be adequately explained as pure chance.

We should agree that improbable events can be surprising or unsurprising. For instance, compare a monkey's typing of "To be or not to be!" to its typing of "e4 t5 ghfdsfg 5%0". Both are equally improbable in respect of having the same form – comprised of 19 characters each from a standard keyboard. But the first sentence's meaningfulness is a special feature which renders it *surprisingly* improbable. Or, if we return to lottery analogy, suppose that Emre wins the lottery repeatedly (example 20 times), and that we come to learn that he is a good friend of the owner of the lottery. Should we not thereby be surprised by his individual victory and feel compelled to seek an alternative explanation than pure chance? Seemingly so. But fine-tuning seems similarly surprising. We ought to consider not merely the probability of our universe in contrast to other potential universes, but rather probability of a life-supporting universe in contrast to life-prohibiting universes. Given that emergence of life supporting universes are extremely unlikely in comparison to life prohibiting ones, and this universe's turning out to be life

[16] J. Koperski, *Physics of Theism*, (Oxford: Wiley-Blackwell, 2014): 66.

supporting seems to be very unlikely. First, like Emre's winning the lottery 20 times, our case seems to be one in which we have won the "cosmic lottery" several dozen times, given that there are many independent parameters which could make life impossible. Second, a universe being hospitable to life seems a special outcome compared to inhospitable universes, as does Emre's being a friend of the owner of lottery or a monkey's typing of "To be or not to be!".Hospitable universes are special not only because they support life, but also because they alone exhibit attributes such as morality, aesthetics, consciousness etc. Thus it seems that fine-tuning requires an explanation beyond pure chance.

5. The Weak Anthropic Principle

Another means of denying the need for an explanation of fine-tuning is to appeal to the so-called 'Weak Anthropic Principle'. According to the weak version of the Anthropic Principle, if the physical laws and constants were not fine-tuned for life, we would not have been here to discover it. Therefore we should be unsurprised by the universe's being fine-tuned for life, for we could not observe any universe other than that which was hospitable to our existence. This is precisely what we should expect; therefore, no explanation of fine-tuning is required. [17]

This objection is now rarely defended, because it seems to be fallacious. Compare saying that a person jumping from the fiftieth floor and surviving the crush should not be surprised, for if he had not survived he would not have been here to question his survival[18]. This is absurd: surviving the jump from fiftieth floor is a rare event which would definitely require an explanation. That a survivor could not question his survival had he not survived does not eliminate the need for explanation. Similarly, what is surprising about our universe is not merely that it is observable by us, but rather the occurrence of a very low probability outcome that we do observe.

6. Other Forms of Life are Possible

One common objection to the fine-tuning argument is that it makes an anthropocentric assumption that only familiar life forms are possible. According to this line of objection, however, there may be possible exotic life forms in universes which we assume are inhospitable to life (Stenger, 2004: 177- 178).

This objection is based on a misunderstanding of the argument. The argument does not make this assumption. As we discussed above, the basic assumption of fine-tuning is the claim that life can emerge only in the universes where physical conditions permit beings which can reproduce, store and use energy. These are

17 Barrow and Tipler, *The Antropic Cosmological Principle,* 1-2.

18 A similar analogy familiar from the literature is Leslie's Firing Squad analogy: J. Leslie, "How to draw conclusions from a fine-tuned cosmos", *Physics, Philosophy and Theology: A Common Quest For Understanding*, ed. R. J. Russell, W. R. Stoeger and G. V. Coyne, (Vatican City State: Vatican Observatory Press, 1988): 297-312.

very minimal requirements for lifeforms. And these features can be realised only in universes where there are chemical elements for forming some sorts of molecules and stable energy sources. Thus the only assumption made by the defender of the fine-tuning argument is that life can only emerge in universes exhibiting stable energy sources. If the objector believes even these minimal conditions too stringent, he at least seems under some burden to expound upon the possible nature of such exotica.

7. The Monkey God Objection

Victor Stenger has objected to the fine-tuning argument on the basis of his 'MonkeyGod' computer program.[19] MonkeyGod is a program which chooses random values for the masses of electrons and protons, as well as the strengths of the electromagnetic force and the strong nuclear force from a given probability density function. He uses 8 different life-permitting criteria:

1. The radius of the electron orbit should be at least 1000 times the radius of a nucleus.
2. The energy of an electron in atom should be less than one thousandth of its nuclear binding energy.
3. The fine structure constant should be smaller than 11.8 times the strong force coupling constant, ensuring a stable nuclei.
4. Stars should have longer lives than 10 billion years.
5. The maximum mass of stars should be at least 10 times greater than the maximum mass of planets.
6. The minimum mass of a planet must be at least 10 times smaller than maximum mass of a planet.
7. The length of a planetary day should at least 10 hours.
8. The length of a year should be greater than 100 days.

He deems the satisfaction of the criteria as necessary conditions for hospitability to life. Stenger claims that his program demonstrates that the emergence of life-permitting universe is not unexpected.

However, Stenger's Monkey God is far from establishing that the universe is not fine-tuned for life. First, his model does not consider the fine-tuning of the laws of nature and the initial conditions of the universe. At most his code can show that the four parameters he uses (mass of electrons, mass of protons, and strength of electromagnetic and strong nuclear forces) are not fine-tuned. But even in this regard he fails. The criteria 7 and 8 are irrelevant: the length of a year or day is an unimportant factor effecting life in general. Criteria 5 is also insufficient: the maximum mass of the star should be greater than the minimum mass of the star.

[19] V. Stenger, *The Fallacy of Fine-Tuning: Why the Universe is Not Designed for Us*, (Amherst N.Y: Prometheus Books, 2011): 233-244.

And Criteria 2, 3 and 5 are wrong - and of course many crucial criteria are missing[20].

This is enough to render his analysis incorrect, but even his probability density function is biased. He uses a logarithmic prior, overestimating the low values of constants where life is possible. Moreover, he centres his range around our universe, essentially making his model biased towards life permitting universes. Lastly his choice of cut-offs for the parameters seems to be arbitrary and not sufficiently high given that there is no limit to their possible values. Given this it seems clear that Strenger's simple model is defective, biased and unthreatening to the fine-tuning argument.

8. The Changing Single Variable Objection

One further objection, again due to Victor Stenger, is that the hypothesis of fine-tuning is based upon an analysis involving variation of one variable whilst keeping others constant:

> …the examples of fine-tuning given in the theist literature . . . vary one parameter while holding all the rest constant. This is both dubious and scientifically shoddy. As we shall see in several specific cases, changing one or more other parameters can often compensate for the one that is changed.[21]

This objection is doubly wrong. First, even were Stenger's claim that fine-tuning calculations are based upon varying single parameters correct, it would not follow that the fine-tuning hypothesis is misguided. Considering multiple parameters may and most probably will lead to bigger parameter spaces of life-prohibiting universes. Moreover, Strenger's claim that only a single variable is varied, whilst others are held constant is clearly wrong. Most of the fine-tuning papers vary more than one variable. For example Tegmark, Aguirre, Rees and Wilczek's paper considers a 7-parameter phase space.[22] [23]

9. Normalisability objection

Lydia McGrew, Timothy McGrew, and Eric Vestrup claim that the probabilities given in the argument for fine-tuning are formally incoherent because they are not normalisable.[24] In order to understand this objection, let us start with a basic example. Think of a fair dice for which, given the Principle of Indifference, the probability of rolling any number is 1/6. Adding the outcomes probabilities gives 1. If all the outcome's probabilities sum to 1, we say that they are 'normalised'. Normalisability is a necessary condition of any coherent Kolmogorovian

20 L. Barnes, "Fine-tuning of the universe for life".

21 V. Stenger, *The Fallacy of Fine-Tuning: Why the Universe is Not Designed for Us*, 70.

22 M. Tegmark, "Dimensionless constants, cosmology, and other dark matters".

23 For a more detailed and complete critique of Strenger's work the reader may consult: L. Barnes, "Fine-tuning of the universe for life".

24 T. McGrew, L. McGrew, and E. Vestrup, "Probabilities and the fine-tuning argument: a sceptical view", *Mind,* 110, (2001): 1027–1038.

probabilistic judgment. In general for any system, with n equally likely outcomes, the normalized probabilities are given by $1/n$. Whilst any probability with a finite range of variables can be easy normalized, infinite sample spaces ($n \to \infty$) prove more problematic:

> Probabilities make sense only if the sum of the logically possible disjoint alternatives adds up to one—if there is, to put the point more colloquially, some sense that attaches to the idea that the various possibilities can be put together to make up one hundred percent of the probability space. But if we carve an infinite space up into equal finite-sized regions, we have infinitely many of them; and if we try to assign them each some fixed positive probability, however small, the sum of these is infinite.[25]

According to the objection, the fundamental constants used in fine-tuning argument - such as strength of gravitational force or the dimensionality of universe - seems to be unbounded: that is, they can take any value starting from zero up to infinity. Given the Principle of Indifference (that all the possible outcomes are equally likely), the normalizability condition seems to be impossible to satisfy. If we assign any finite number (no matter how small) as the probability to the possible outcomes of these constants, we result in infinite total probabilities. On the other hand if we assign zero probability to all the possible outcomes, we end up having total probabilities of zero. Thus - the objection claims - since they are not normalizable, the fine-tuning argument's main claim that life-permitting universes are extremely unlikely is meaningless.

There are two possible replies to this objection. First, the defender of the fine-tuning argument may reject the Principle of Indifference. In most of the real calculations of the possible ranges of the constants of nature an appropriate cut off is chosen, such that the values above this cutoff are assigned zero probability. Lydia McGrew, Timothy McGrew, and Eric Vestrup assume that only non-arbitrary comparison for a physical constant is to take all their logically possible values. But there may be other non-arbitrary ways to compare them. One may give some physical arguments for restricting them to some finite range. Or one may choose a cut-off value, based upon the observation that the higher outcomes produce the same result. For example, if the strength of the electromagnetic force is greater than the strong nuclear force, then atoms with higher atomic numbers than hydrogen cannot be formed, because protons cannot be held at the nucleus. Hence physicists may choose to restrict the strength of the electromagnetic force with that of the strong nuclear force, and to calculate the fine-tuning of the strength accordingly. Or if the strength of the gravity is stronger than a certain value, the universe will collapse after the big bang prior to the formation of galaxies. One may thus want to restrict the strength of the gravity below the smallest value for which a universe collapses before galaxies are formed.

[25] T. McGrew et al, "Probabilities and the fine-tuning argument: a sceptical view", 1030.

Secondly, although McGrews and Vestrup do not openly state as such, they also assume the principle of countable additivity.[26] The principle of countable additivity states that for any countable probability outcomes, the probability of any disjunction of these outcomes is equal to the sum of the corresponding probabilities of these alternatives. Whilst principle of countable additivity clearly applies to systems with finite outcomes, it is not clear whether it is also applicable to infinite probability spaces. Hence a defender of the fine-tuning may reject Principle of countable additivity instead of the principle of indifference. If the principle of countable additivity is not valid, then we can assign zero probabilities to each of the states and claim that the total probability nevertheless equals one. For example, assume we have a single electron in spatially infinite universe, if the velocity of the electron is completely known (hence it is in plain wave state) and its position completely unknown. The probability of finding this electron in any particular point in space will be zero. But nevertheless it will definitely be somewhere in the universe. Hence the principle of countable additivity seems to fail for the electron in infinite space, and therefore we can say that it also fails for the case of the fine-tuning of physical constants. Therefore, the normalisiblity objection fails.

To conclude, the ranges of the fundamental constants can be restricted to finite sizes using non-arbitrary cut offs, hence solving the problem of the normalisability. If the objector is willing to press the objection and claim that all the cut offs are *ad hoc*, and insists upon an infinite range, the normalisability objection can alternatively be handled by rejecting the Principle of Countable additivity in cases of infinite equiprobable outcomes.

Conclusion

Modern physics has shown that the universe is fine-tuned for life: that of all the possible ways physical laws, initial conditions and constants of physics could have been configured, only an extremely small range is capable of supporting life. Despite the initial appeal some philosophers and scientists have denied the need of explanation for the fine-tuning. They either deny that the universe is fine-tuned for existence or else think that we should not be surprised that universe is fine-tuned, and therefore should not search for explanation. In this paper we analysed six objection which follow these strategies: the claim that pure chance can account the fine-tuning, weak anthropic principle objection, the charge of anthropocentricity, the normalisation objection and Strenger's single variable and monkeygod objections. We tried to show that neither of these objections are capable of undermining the need for explanation of fine-tuning of the universe.

[26] A. Plantinga, *Where the conflict really lies*, (New York: Oxford University Press, 2011).

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