Is the Universe Designed?

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Summary

The universe appears to be fine-tuned so as to admit the development of life. This paper examines the evidence for fine-tuning and the chief rival explanation to design, namely the existence of a 'multiverse'.

Introduction

'Like the porridge in the tale of Goldilocks and the three bears, the universe seems "just right" for life, in many intriguing ways.' So says cosmologist Paul Davies in his book *The Goldilocks Enigma*.[1] If the universe was created by the God of the great monotheistic religions, this is not surprising: God would have good reason for creating a universe with properties such that intelligent creatures could evolve who would be capable of a relationship with him. The chief alternative to this 'design' hypothesis is the existence of a multiverse, a vast ensemble of universes in which the parameters of physics take on a wide range of values. This paper exposes numerous problems with the multiverse hypothesis, and argues that divine design is much the more rational explanation on the basis of the cosmological data.[2]

The Big Bang

It is now accepted by the vast majority of cosmologists that the universe began in a hot, dense state approximately 14,000 million years ago. From the expansion and cooling of the primordial fireball evolved the galaxies, stars and planets of the universe that we observe today. This is the standard Big Bang model of the origin of the universe.

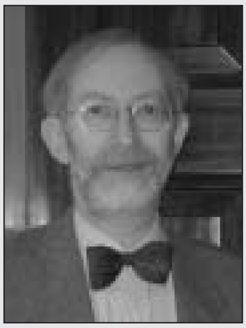
The key observation giving rise to the Big Bang theory was made by Edwin Hubble in the 1920s. This is that the universe is expanding, that is, distant galaxies are receding from us. The natural conclusion to draw from the expansion is that the matter of the universe was more compact in the past, indeed that the present universe must have evolved from a very dense, initial state. However, that did not stop Cambridge astrophysicist Sir Fred Hoyle and colleagues proposing, for philosophical as much as scientific reasons, the alternative steady state theory.[3] According to the latter the universe is eternal, looking essentially the same at all times and all places on the largest scales, and the gaps left by the expansion are filled with new matter continuously created at just the right rate.

The Big Bang theory, however, is convincingly supported by three main strands of observations.

1. The theory predicts a uniform, remnant radiation field bathing the universe. This, the cosmic microwave background radiation, has been observed, effectively eliminating the steady state theory which could not explain it.
2. The theory correctly predicts the abundances of the lightest chemical elements (notably helium and the deuterium isotope of hydrogen) which it explains as being formed from nuclear reactions in the first minutes of the universe's existence. Astrophysicists were unable to explain the production of these elements with models of nucleosynthesis in stars, the other great nuclear furnaces of the universe, so light element production in the Big Bang completes a satisfying account of how the elements heavier than hydrogen are manufactured.
3. Observations show a greater number of active galaxies at the greatest distances (which, because of the finite speed of light, correspond to the earliest times in the universe's history). The Big Bang theory would lead one to expect such signs of cosmic evolution, whereas, on the steady state theory, the universe would look the same at all epochs.

According to the Big Bang theory, then, space and time came into existence together some 14,000 million years ago. Incidentally, St Augustine of Hippo as long ago as AD 400 had come to the conclusion that space and time came into existence together,[4] one of a number of instances where Christian theologians of earlier epochs have pre-empted modern discussions.

Turning the clock forward from the Big Bang, as the expansion progressed the matter formed into clumps which became galaxies. Within the galaxies stars formed. The original constituent of the Big Bang, bequeathed to the galaxies, is the simplest chemical element, hydrogen, with some helium and light elements. The other chemical elements are built up in the cores of stars, where temperatures reach hundreds of millions of degrees. When their nuclear fuel runs out, the most massive stars explode in spectacular fashion as super-



About the Author

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1 Davies, P.C.W. *The Goldilocks Enigma: Why is the Universe Just Right for Life?*, London: Allen Lane (2006).

2 A much fuller, technical account of the topics considered in this paper is given in the author's *God, the Multiverse, and Everything: Modern Cosmology and the Argument from Design*, Aldershot & Burlington, VT: Ashgate (2004). The present paper is based on Holder, R.D. 'Fine Tuning and the Multiverse', *THINK*, (Royal Institute of Philosophy), Issue 12 (Spring 2006), pp. 49-60, and is reproduced by permission.

3 See, for example, Hoyle, F. *Frontiers of Astronomy*, London: Heinemann (1955); Bondi, H. *Cosmology*, Cambridge: Cambridge University Press (1961).

4 Augustine, St *The City of God*, XI.6, in Schaff, P. (ed.), *Nicene and Post-Nicene Fathers*, First Series, vol. 2, Peabody, MA: Hendrickson (1994).

novae. Subsequent generations of stars are therefore formed out of material enriched with the heavier chemical elements. Hence newer stars can also have planets.

The sun with its planets was formed some 4.6 billion years ago. Since the chemical elements of which the earth and everything on it are made were built up inside the cores of earlier generations of stars, we can say that 'we are made of the ashes of dead stars'.

The fine-tuning of the universe

The so-called *anthropic principle* states that the laws of physics and the initial conditions at the Big Bang must be such as to make our existence possible.[5] Moreover, analysis shows that both the laws and initial conditions have to be very special indeed – 'fine-tuned' – for this to be the case.

'A commonsense interpretation of the facts suggests that a super-intellect has monkeyed with physics, as well as with chemistry and biology'

The number of examples of fine-tuning is legion. Let us examine just a few of them to set the scene.

A. *Physical constants*

The laws of physics describe how matter behaves under the influence of the four fundamental forces of nature (gravity, the electromagnetic force, and the strong and weak nuclear forces). For our purposes we are interested in the constants which determine the relative magnitudes of these forces, and the values of other important quantities such as particle masses.

(i) One of the most important elements necessary for life, certainly life as we know it, is hydrogen – no hydrogen means no water and hence no life. If the weak nuclear force, the force responsible for radioactive decay, were not, apparently accidentally, related to the gravitational force in a rather special way, either all the hydrogen would be converted to helium within a few seconds of the Big Bang or none would be converted. In the former case, with the weak force somewhat weaker, one would end up with no possibility of water or life at any subsequent stage in the universe's history. Moreover, the requirement that massive stars explode in supernovae, to release the chemical elements they have manufactured, constrains the relationship between the weak force and gravity in both directions.

(ii) Life as we know it is based on the element carbon, and it is unlikely that any other element could give sufficiently stable compounds to produce alternative life forms. Oxygen is also essential. Carbon is one step on the way to manufacturing oxygen and the other elements in the periodic table. We are required both to get as far as carbon in the first place and then, even more delicately, not to burn up all the carbon in manufacturing oxygen and the other elements. If the strong nuclear force, which binds nuclei together, and the electromagnetic force, which operates between charged particles, were not so very finely balanced as they are, we would either get no carbon in the first place or all the carbon would burn, making oxygen. This aspect of the anthropic argument was discovered by Fred Hoyle, who used it to predict the existence of a previously undetected energy level (resonance) in the carbon-12 nucleus. His prediction was confirmed by somewhat sceptical experimental nuclear physicists. Hoyle himself (a sceptic in religious matters, who, as noted above, had philosophical reasons for proposing the steady state theory) was so impressed by this particular coincidence, that he was moved to remark:

> If you wanted to produce carbon and oxygen in roughly equal quantities by stellar nucleosynthesis, these are just the two levels you would have to fix, and your fixing would have to be just about where these levels are actually found to be ... A commonsense interpretation of the facts suggests that a super-intellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question.[6]

(iii) Thirdly, the mass of the proton must be almost exactly 1840 times the mass of the electron, as it is, for the possibility of interesting chemicals to be made and to be stable, certainly for complicated molecules like DNA which are the building blocks of life.

B. *Initial conditions*

(i) First, the mean density of matter in the universe at the very beginning has to be within 1 part in 10^{60} of the so-called 'critical density' which demarcates universes which are open (expand forever) from those which are closed (recollapse to a 'big crunch'). If the density is smaller than it is by this amount then the universe will expand far too quickly for galaxies and stars to be able to form. If it is greater then the whole universe will recollapse under gravity in just a few months. Either way you have a boring universe with no possibility of life. An accuracy of 1 part in 10^{60} is that required to aim a gun at a coin 14 billion light years away at the opposite end of the universe and hit it!

(ii) Secondly, and related to the above, contrary to our intuitions, it turns out that the universe needs to be the vast size it is in order for humankind to exist.[7] This is the size which an expanding universe with density close to the critical value reaches in the 14,000 million years which it takes to evolve human beings. In the simplest cosmological model (which is fine for this purpose) the size, mass and age of an expanding universe are connected by a simple formula. A universe with the mass of a single galaxy has enough matter to make a hundred billion stars like the sun, but such a universe would have expanded for only about a month so that no stars could yet have formed in fact. Thus the argument that the vastness of the universe points to man's *insignificance* is turned on its head – in reality only if it is so vast, containing a hundred billion galaxies, could we be here!

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(iii) Thirdly, there must be an incredibly precise amount of order at the Big Bang. We know that the universe is moving from a state of order to a state of increasing disorder (this is the Second Law of Thermodynamics), and it is the case that you needed a lot of order at the beginning for the universe to be able to produce galaxies and stars, the ordered structures we see. Sir Roger Penrose, emeritus professor of mathematics at Oxford, has shown that our universe was one of $10^{10^{123}}$ possible universes only one of which would have had the amount of order in it required to produce the complexity we observe.[8] Something like this amount of order was needed so that we could be here. Supposing you were to write down $10^{10^{123}}$ writing a nought on each atom in the universe, there would not be enough atoms in the entire visible universe to enable you to do this.

In a nutshell, the universes potentially generated by these tiny alterations have no scope for interesting developments, and in particular the evolution of complex creatures like ourselves to observe them. And of course physicists have been struck by these coinci-

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5 Barrow, J. D. and Tipler, F. J. *The Anthropic Cosmological Principle*, Oxford: Oxford University Press (1986).

6 Hoyle, F. 'The Universe: Some Past and Present Reflections', *Engineering & Science*, (1981), p. 12.

7 Barrow and Tipler, *op. cit.*, (5), pp. 384-385.

8 Penrose, R. *The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics*, Oxford: Oxford University Press (1989), pp. 339-345.

dences. As Freeman Dyson puts it: ‘The more I examine the universe and the details of its architecture, the more evidence I find that the universe in some sense must have known we were coming.’

There is a very natural conclusion to draw from all this, namely that the cosmic coincidences we have been considering are indeed no accident: the theistic hypothesis that God designed the universe with the express intention of producing rational conscious beings, with a moral sense, to contemplate his handiwork and to enter into a relationship with him, is surely preferable. The *hypothesis of theism* can advance reasons why God might create a universe, and in this particular way. For example, a good God, as postulated by Christianity, is likely to exercise his creative power and to produce beings able to appreciate his work. Such a scenario is certainly consistent with the finely tuned universe that we observe.

Alternatives to design

One might ask how it is possible to escape the conclusion that the universe is designed expressly in order for us to be here. In fact there are a number of possible ways out. One idea has been to say, ‘Can't we come up with a better, more fundamental theory, which actually predicts some of the numbers you have been talking about?’ The main contender for such a theory in recent years is called ‘inflation’, because it postulates a period of incredibly rapid expansion of the universe in the first 10^{-32} seconds of its existence, followed by the normal, relatively sedate standard Big Bang expansion. The argument is that the universe would then tend automatically to the critical expansion rate, for example.

There are two problems with this approach. First, a more fundamental theory doesn't in any case negate the need for design by God, because now we simply ask, ‘Why does the new fundamental theory give the values it does to the numbers we have been talking about?’ The amazement we felt at the fine-tuned numbers just translates to amazement at the theory which can produce them. Why should *that* theory, of all possible theories, be instantiated? But secondly, inflation itself needs fine-tuning! In order to fit the facts, inflation has gone through well over a hundred different versions at the most recent count, including even one version called ‘supernatural inflation’.[9] Even the originator of inflation, the American cosmologist Alan Guth, says he can't keep up with this! The inflation industry seems to be victim to a severe case of inflation itself, rather akin to the epicycles upon epicycles required to keep the Ptolemaic model of the solar system compatible with observation. On the other hand, whilst some cosmologists such as Penrose are sceptical, it must be acknowledged that inflation is widely believed in the cosmological community, and has recently acquired significant support from the latest satellite observations of the cosmic background radiation.

The chief argument opponents of design have come up with is as follows: they argue that if not just one but many universes exist, and if the constants of nature and the initial conditions at the Big Bang take on lots of different values, then we might get a universe like ours as one of this collection of universes (called a multiverse). We are not then supposed to be surprised to exist in a universe with the very special conditions ours has, since we couldn't exist in the other universes, even those where conditions were ever so slightly different.

Cosmologists envisage a number of possible ways of obtaining infinitely many universes, of varying plausibility, as I mention briefly below. Is it, then, a question of, ‘You pays your money and you takes your choice’? Or is there any way of deciding between these competing explanations?

9 Shellard, E. P. S. ‘The Future of Cosmology: Observational and Computational Prospects’, In Gibbons, G. W., Shellard, E. P. S., & Rankin, S. J. (eds), *The Future of Theoretical Physics and Cosmology: Celebrating Stephen Hawking's 60th Birthday*, Cambridge: Cambridge University Press (2003), p. 764.

Problems with multiverses

This idea of the existence of many universes is actually riddled with problems.

(i) For a start, these universes are completely unobservable. A theory is only really scientific if it makes predictions about things we can observe and the multiverse idea fails this test disastrously. The problem is that we cannot even in principle have any contact with the other universes. The most obvious way to envisage many universes is as different, even if enormous, regions within one overarching universe. This picture has been given credence by inflationary theory which, in some versions, notably Andrei Linde's ‘eternal inflation’, gives rise to bubble universes incapable of contact with one another because of the speed of light constraint. Attempts are being made to link eternal inflation with string theory, the chief candidate for the combined theory of quantum mechanics and gravitation, which is required to describe the first 10^{-43} seconds of the universe's existence. But the problem with all such models is that we simply cannot know the other universes are there.

Other ways of getting many universes envisage them as even more radically separate from our universe (e.g. if they arise through successive expansions and contractions of one universe, or through the actualisation in some sense of the alternative outcomes of quantum measurements). Interestingly, cosmologist Stephen Hawking has stated that he no longer believes an earlier proposal he made, namely that new universes can branch off from ours at the centres of black holes.[10]

As John Polkinghorne points out, the existence of many universes provides, not a scientific, but a metaphysical explanation of the fine-tuning of this universe.[11] The reason is that the existence of these worlds is completely insensitive to any empirical data – they are unobservable. The fact is that, whether we like it or not, we are faced with alternative metaphysical explanations: that is, either the universe is unique and a brute fact, or there is a multiverse, or the universe is designed (although we consider these to be the main options, there is also the logical possibility that God designed and created infinitely many universes).

(ii) There are also severe technical problems with the idea of the multiverse. Thus it is hard to escape the need for some parameters to be special, even to obtain many universes in the first place. I mentioned earlier how the mean density of the universe needs to be very close to the critical value which is the borderline between a universe which will expand forever and one which will eventually recontract. Well, you need the mean density in the overarching space-time to be below the critical value so as to get an infinite cosmos and there is no reason why that should be. Indeed on the face of it, this would seem very unlikely. In any case we can never actually know the mean density of an infinite cosmos – it is beyond the reach of our measurement in principle, not just in practice.

(iii) Then, as Barry Collins and Stephen Hawking pointed out a long time ago, the probability that any particular universe is just right for life is zero.[12] That means that even an infinite number of universes by no means guarantees even one that is right for life. Many universes might explain why there exists a very special universe like ours if, when you draw a universe out of a hat, the probability that it is right for life is positive. That probability could be very small but it does need to be positive. If the probability is zero the explanation fails.

(iv) A further problem is the question of what a life-bearing universe would look like if it were a random member of a multiverse. On the multiverse hypothesis, our universe would be special, yes, but not more special than is required for our evolution. Some physi-

10 Hawking, S. W. Lecture at the 17th International Conference on General Relativity and Gravitation held in Dublin in July 2004.

11 e.g. Polkinghorne, J. C., *Reason and Reality*, London: SPCK (1991), p. 79.

12 Collins, C. B., and Hawking, S. W. ‘Why is the Universe Isotropic?’, *Astrophysical Journal* (1973) 180, 317-334.

cists, notably Steven Weinberg, claim success for the multiverse in explaining why one particular constant, the so-called cosmological constant, is so low.[13] This constant is sometimes referred to as ‘dark energy’ and is believed to contribute 70% to the composition of the universe; note that things are somewhat more complicated than we have outlined above: the constituents of the universe are currently believed to be approximately 5% ordinary matter, 25% some sort of unknown ‘dark matter’, and 70% dark energy, their sum comprising roughly the critical density.

It is believed that dark energy results from fluctuations in the quantum vacuum, though its density is no more than 10^{-120} times what would be expected on the basis of such calculations. A multiverse might just explain why the cosmological constant is so low in our universe, because a low value is required for galaxy formation and hence for our existence.

(v) However, there is a much worse problem which a multiverse seems powerless to explain. This problem is rather like the monkey sitting at a typewriter for centuries. It is vastly more likely to produce ‘To be or not to be’ at some stage than the whole of *Hamlet* (although, interestingly, in an experiment in 2002 a group of monkeys came nowhere near producing even a word, and much preferred to chew up the computer or use it as a toilet[14]). In a similar way we are far more likely to find ourselves in a small pocket of order, say of the size of the solar system, surrounded by total chaos, than we are to find ourselves in the totally ordered cosmos we actually observe.

Sir Roger Penrose has quantified this effect.[15] I described earlier how our universe possesses order to the degree 1 in $10^{10^{123}}$. In fact, to make only a solar system, surrounded by chaos, by the random collisions of particles, which is all that is required to make life, the order required is much less than this, though still vast. It is 1 in $10^{10^{60}}$. Since $10^{10^{123}}$ swamps $10^{10^{60}}$ completely, what that means is that, although a universe with order 1 in $10^{10^{123}}$ exists with probability 1 if all possible universes exist, *the probability of our observing such a universe* is only 1 in $10^{10^{123}}$. This is quite contrary to the normal assumption made that the probability of our observing what we do is close to 1 on the basis of a multiverse. This severely undermines the explanatory power of the multiverse. It is important to note that what matters is not the probability that a universe like ours exists, but the probability that we observe what we do, and we are vastly more likely to observe a small pocket of order surrounded by chaos than a totally ordered universe.

(vi) There is also the question of what we imagine the universes in the multiverse would look like in general. One is virtually forced to speculate, way beyond anything physics can say, that all possible universes exist, in order to guarantee one like ours coming about. Most of these universes would be dead. Of the tiny minority that had life at all, some would really have mythical creatures like unicorns, werewolves and animagi. Some would have vastly more suffering than there is in our world. Indeed on this view anything that could happen would happen, somewhere sometime. If this were the case then doing science would be a complete waste of time. Instead of trying to find reasons for things, we could simply shrug our shoulders and say, ‘Well, something like that is bound to happen in some universe, and that’s the one we happen to be in.’ And that is very damaging for science.

(vii) Finally, the experience of scientists shows that the simpler the explanation the more likely it is to be true. And simple is just what the many universes theory is not. There is a principle called Ockham’s razor, after the 14th century philosopher and theologian William of Ockham, which states that if you have competing alternative explanations, you should choose the one which is the most economical, positing the least number of entities. Multiverse theories violate Ockham’s razor in just about the most extreme way imaginable.

Conclusion

The purpose of this paper is not to develop the alternative of divine design in any detail, but rather to critique some of the arguments suggesting that the universe is not designed. However, there is a strong argument that divine design represents a much simpler and more economical explanation for the existence of our very special universe, and that, in contrast to what is expected on the multiverse hypothesis, we are very likely to observe a fully ordered cosmos if God has designed it. Indeed the theistic hypothesis provides a much more comprehensive explanation. This is because God, as traditionally conceived, is necessary and a physical universe or even a multiverse is contingent. That is to say, God cannot but exist and must possess the properties he does, of omniscience, omnipotence and so on. This is at least part of what the concept of God means. In contrast the universe may or may not have existed and could be different from what it is. The same is true of a multiverse, and indeed the question of the specialness of our universe is not resolved by a multiverse but only transferred to it. Why does a multiverse exist and why *this* multiverse? God as necessary being both provides an explanation for why anything exists at all and a reason for the universe being so special, indeed super-special, as to produce us.

Furthermore, whilst one cannot observe God, any more than one can observe a multiverse, unlike the case of a multiverse there is no reason in principle why God cannot have observable effects in our universe. Christians claim that there are many such effects, including the incarnation of God himself, all of which of course need to be examined in an evaluation of their authenticity.

In the end, surely it is far more rational to believe that the universe was deliberately designed by God, with the express intention of producing intelligent beings with the capacity for a relationship with their Maker, than the alternative of a multiverse minus God. Indulging in wild and totally unscientific speculation about hypothetical, unobservable universes, the vast majority of which are completely dead and boring, in order to explain the very special nature of this particular one, looks irrational.

13 Weinberg, S. ‘The Cosmological Constant Problem’, *Rev. Mod. Phys.*(1989) 61 (1), pp. 1-23; Weinberg, S. ‘Theories of the Cosmological Constant’, arXiv:astro-ph/9610044 v1 7 October, talk given at the conference *Critical Dialogues in Cosmology* at Princeton University, 24-27 June 1996.

14 *Notes Towards the Complete Works of Shakespeare* by Elmo, Gum, Heather, Holly, Mistletoe and Rowan, Sulawesi Crested Macaques (Macacanigra) from Paignton Zoo Environmental Park (UK), first published for vivaria.net in 2002; the experiment was carried out by students from the University of Plymouth’s MediaLab Arts course.

15 Penrose, *op. cit.*, (8), p. 354.

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