Anthropic Reasoning and the Contemporary Design Argument in Astrophysics: A Reply to Robert Klee

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Abstract. *In a recent study of astrophysical "fine-tunings" (or "coincidences"), Robert Klee critically assesses the support that such astrophysical evidence might be thought to lend to the design argument (i.e., the argument that our universe has been designed by some deity). Klee argues that a proper assessment indicates that the universe is not as "fine-tuned" as advertised by proponents of the design arguments. We argue (i) that Klee's assessment of the data is, to a certain extent, problematic; and (ii) even if Klee's assessment of the data is correct, it provides a necessary but not a sufficient response to the design argument. However, an adequate skeptical rejoinder to the design argument can be made by appealing to the anthropic principle.*

1. Introductory: Pythagoras, Klee, and Anthropic Fine-tunings

The validity and meaning of the so-called 'fine-tunings', underlying the anthropic principle, has always been highly controversial.[1] In a recent interesting critical study, colourfully entitled "The Revenge of Pythagoras: How a Mathematical Sharp Practice Undermines the Contemporary design Argument in Astrophysical Cosmology," Robert Klee criticizes both the mathematics and physics of (putative) fine-tunings, in order to show that the teleological conclusions drawn from them are ill-founded (Klee 2002). Klee's primary target is a contemporary design argument that invites us to believe that the best explanation for the apparent fine-tuning of certain astrophysical numbers is that our universe was designed by a deity. Clearly there are at least two possible means to criticize the theist's argument: one could challenge the *significance* of the astrophysical numbers, or one could challenge the numbers themselves. Klee takes the latter (uncommon) approach. While the ultimate target of Klee's criticism is the design argument, often the proximate target is anthropic reasoning and the anthropic principle. The

term ‘anthropic principle’ comes from Carter (1974), and refers to the idea that the values of fundamental constants of our universe are (purportedly) highly constrained by the contingent fact that human observers exist: what might otherwise seem to be possible values for the fundamental constants can be ruled out because they are inconsistent with (say) the existence of stars that are stable for billions of years, or with the existence of supernovas. The ‘anthropic thinking’ here is that both stable stars and supernovas are necessary for the evolution of intelligent life: the former as a home and energy source for life to evolve, the latter to produce the heavier elements in the periodic table necessary for many life processes. Klee considers almost exclusively theistic applications of anthropic reasoning; such reasoning invites us to infer abductively from the fact that our universe has such a precise set of fundamental constants to the conclusion that our universe has been designed by a deity. So, in criticizing anthropic reasoning, Klee understands himself to be undercutting the argument from design.

While we are sympathetic to the conclusion that Klee draws, namely, skepticism about the soundness of the design argument, we believe that his argument is deficient. The paper divides into two parts. First, we critically assess Klee’s attempt to show that the astrophysical numbers are not as finely tuned as has often been alleged; we argue that Klee’s corrective is itself not without errors. Second, we show that, even if Klee’s reassessment of the astrophysical data is correct, nevertheless; this in itself does not undercut the argument from design, since Klee’s argument is open to a plausible theistic rebuttal. Specifically, we find that Klee’s argument provides a necessary but not sufficient response to the design argument. To shore up skepticism about the design argument, we show that the atheist may appeal to anthropic reasoning.

2. Getting the Numbers Right

Klee’s major complaint against the contemporary design argument in astrophysics is that it employs what he terms a ‘mathematical sharp practice’. The term ‘sharp practice’ is borrowed from the legal tradition: “…a practice that, while technically not illegal, is nevertheless shrewdly self-advantageous to the point of being seriously misleading” (p. 333). Among the sins covered by the idea of mathematically sharp practices are: imprecision in quoting dimensionless ratios of fundamental constants

and cosmological parameters, and stretching of the meanings of terms "of the same order of magnitude" or "of similar order of magnitude". Klee finds examples of sharp practice throughout the history of anthropic thinking, from Weyl and Eddington to the monograph of Barrow and Tipler (1986).

In most general terms, surely Klee is correct to condemn mathematical sharp practice—wherever it may occur. Thus, he is correct that, if the design argument is to be considered sound, then it is important that the numbers that are cited in support of "fine-tuning" (or coincidences) are trustworthy, and in no way simply the result of some mathematical sharp practice. While we believe that there are many pieces of his analysis that are error-free, and perhaps should have been said long ago; nevertheless, we have some general and specific worries about Klee's treatment of the astrophysical data. Indeed, we believe there is room to wonder whether Klee himself is guilty of mathematical sharp practice.

A very general concern arises from Klee's treatment of the astrophysical data in Table 1—the centrepiece of his article. Here he places in the same column (i) values which are known to one part in a thousand or better (like proton mass), (ii) values which of necessity vary within one order of magnitude (like human length and mass), and (iii) those which—although determined well-enough—span several orders of magnitude due to the different physics involved (like the planetary masses), and, finally, (iv) those which are plainly unknown, remaining uncertain to within more than an order of magnitude (like galactic masses). From a basic high-school (or undergraduate) course in statistics and data analysis, one may learn that unweighted averages of highly uneven data are worthless. However, Klee does not hesitate to quote five decimal places without any noticeable doubt in worthiness of these results, just as schoolchildren often use their calculators, without realizing that uncertainties cut your decimal calculation at (say) the first decimal figure. "Oh, the cheapness of mindless calculation in this modern age!"—the exclamation of Sir Roger Penrose (1991, p. 25) comes appropriately to mind. So one may wonder whether Klee himself is guilty of "cooking" numbers (to invoke Klee's own phrase) in order to suit his arguments, that is, indulging in "sharp practice"!

2.1 Galactic Mass: Fine-tuned or Not?

To secure this point, let us consider Klee's discussion of galactic mass and size in Table 1 as instructive. Selecting this example seems more than fair, since Klee chooses as main targets of his criticisms *astrophysical* cosmologists. Therefore, it seems most appropriate to discuss those entries in Table 1 that most directly touch upon our astrophysical knowledge, (as opposed to other measures cited in the table less directly related, e.g., the size and mass of elementary particles or human beings). Let us begin with a very general point: if one wishes to draw conclusions dealing with the history and philosophy of science, one would do very well to first ascertain the fine details in each particular discipline that rarely find their way into textbooks and other polished presentations, for here it is where one will often find "awful truths". One of the "awful truths" of astrophysical science is that our knowledge of the mass and size of galaxies is highly uncertain: these uncertainties are of an order of magnitude or greater. Even in our present state of ignorance, however, it is clear that most of the matter in any galaxy is located in the dark halo, and that everything visible—technically speaking, what is contained within the Holmberg radius of a galaxy, typically about 20 kpc (kiloparsecs, 1 kpc = 3.09×10^{19} m)—is just the proverbial "tip of the iceberg", never more than about 20% of the size and 10% of the mass of the whole (and often much less). It is a daunting observational task to determine these parameters exactly, and it is not disgraceful to admit that we still *do not know* the mass of even our own galaxy (the Milky Way)—not to mention other galaxies—with any great deal of precision. Thus, even if there is a claimed anthropic "prediction" of values of these quantities, it seems clear that we cannot at this stage justly assess the value of such a prediction.

To see this, consider that in Table 1, Klee uses the value of 10^{41} kg to represent the mass of the Milky Way, which is about 5×10^{10} $M_\odot$ (Solar masses, 1 $M_\odot = 1.989 \times 10^{30}$ kg), which is very far off the mark, being certainly too small. We shall quote only a handful out of a host of measurements performed in the last decade, in order to show the complexity of the problem. By considering the Milky Way's outer satellites, Kulessa and Lynden-Bell (1992) obtained a mass of around 1.3×10^{12} $M_\odot$ within 230 kpc. The inner part of the Galaxy is accessible to measurements via the high-velocity stars; using this technique, García Cole et al. (1999) estimate the mass within 45 kpc to be 5×10^{11} $M_\odot$, still an order of magnitude larger than Klee's value. Kochanek (1996), using several methods concordantly, obtains similarly (4.9 ±

1.1) × 10^{11} $M_\odot$ out to the galactocentric distance of 50 kpc. Finally, Wilkinson (2000) suggests $1.9^{+3.6}_{-1.7} \times 10^{12}$ $M_\odot$ with the scalelength of 170 kpc.

Similar data is available for other giant spiral galaxies comparable to the Milky Way in luminosity and other properties. The best studies so far have been performed by Dennis Zaritsky and his coworkers, on the basis of observations of satellite galaxies. Zaritsky and White (1994) claim the average mass of a spiral galaxy to be 1.5-2.6 × 10^{12} $M_\odot$ within 200 kpc. In continuation of that study, Zaritsky et al. (1997) confirm the average mass to lie "in excess of 2 × 10^{12} $M_\odot$" with strong dynamical indications that dark haloes extend to more than 400 kpc! In any case, Klee's fiducial radius of about 2 kpc (about 6 × 10^{19} m) is flabbergastingly wrong (being, for instance, more than 4 times smaller than our own distance from the Galactic centre!). Thus, one of the biggest inaccuracies of "anthropic" predictions in Table 1 is simply a consequence of the two orders of magnitude error on Klee's part.[2] Carr and Rees can be forgiven an error like this, since most of this modern galactic astronomy was completely unknown in the late 1970s; but should not be overlooked by Klee, who writes in 2002, well after what, in effect, has been a revolution in our understanding of the nature of galaxies. As Earman (1995, p. 268) cogently notes: "...it needs repeating that philosophy of science quickly becomes sterile when it loses contact with what is going on in science."

The same imprecision may be applied to quantities such as stellar mass and length, since (if we forsake vulgar heliocentrism!) these quantities are not unmistakably or fairly represented by their Solar values, which Klee uses to check the accuracies of the anthropic predictions. This is not to say that the values thus obtained would be very different from the value Klee uses (Solar values); and it is even probable that the discrepancy with the anthropic predictions would be even larger in these cases (since, for instance, the average stellar mass is obviously lower than 1 $M_\odot$, no matter which stellar mass function turns out to be the best). But these empirical findings of astrophysics must be taken ino account if one purports to seriously discuss astrophysical quantities. To not do so would usually bias us towards (and not against) our privileged position in the universe!

The desired net result of Klee's entire numerical exercise concerning the purported fine tuning of the galactic mass is to somehow show that the "enthusiasts" of the anthropic principle are less precise

than its detractors. The reality is, however, that neither is very precise. The considered judgment here, contra some design argument proponents and Klee, is that, to invoke another phrase from the legal tradition, "the jury is still out".

2.2 Nucleosynthesis: Fine tuned or Not?

Our second case for further scrutiny is Klee's interpretation of the (in)famous story about fine-tunings associated with carbon-12. While this presents us with a whole nest of interesting and controversial issues, we shall, for the sake of brevity, confine ourselves to a single point: Klee's use of contemporary research into the anthropic significance of the nuclear resonances in light elements. Klee concludes this section (6) of his paper with the following remark: "The quantitative details are thorny and depend on the specific model of stellar structure used, but the width of the window of compatibility appears to be wide enough to undermine any claim that we have a case of fine tuning on our hands" (347). Klee attempts to support this contention by citing empirical research—but herein lies the problem: this is a sizeable subfield of anthropic research, and there have been several important references dealing with it (Livio et al. 1989; Pochet et al. 1991; Oberhummer, Csoto, and Schlattl 2000; Hogan 2000). Unfortunately, Klee cites just one of these modern studies, and the oldest one at that (Livio et al. 1989), whose results (as Klee correctly sees) could be called critical toward the conventional anthropic view of these nuclear resonances. This selective approach creates an impression that modern research has somehow disproved Hoyle, Barrow and Tipler and others who perceive something important in these data, and in need of an explanation. This impression is misleading. Other studies (and subsequent to Livio et al.) report different results, and much more in the spirit of the idea that reality is fine tuned. For example, Oberhummer et al. (2000) emphasize that (p. 90)

> ...a change of more than 0.5% in the strength of the strong interaction or more than 4% change in the strength of the Coulomb force would destroy either nearly all C or all O in every star. ... Therefore, for the above cases the creation of carbon-based life

> in our universe would be strongly disfavoured. The anthropically allowed strengths of the strong and electromagnetic forces also constrain the Higgs vacuum expectation value... and yield tighter constrains on the quark masses than do the constrains from light nuclei... Therefore, the results of this work are relevant not only for the anthropic cosmological principle..., but also for the mathematical design of fundamental elementary particle theories.

That Klee fails to discuss or at least cite this (and other recent studies) seems to be a case of being shrewdly self-advantageous with the data to the point of being seriously misleading, that is, of engaging in sharp practice.

Of course, one may always claim that 0.5% or 4% are a far cry from "fantastical precision"; but the very point (as we shall argue) is that obtaining such "fantastic precision" is not necessary to vindicate the anthropic principle. Oberhummer et al. are certainly conscious that 4% is not "fantastic precision" by every standard when they invoke anthropic considerations, but they are not seeking such precision; rather, they seek—along the entire scientific, notably physical tradition—something infinitely more important: an explanation. That is, what, if anything, explains the fact that our universe has values that fall within such a narrow range compatible with life? To this question we now turn.

3. The Significance of Fine Tuning: Observation Selection Effects *vs.* the design Argument

As noted above, we believe that there are many pieces of Klee's analysis that are error-free, and perhaps should have been said long ago. Furthermore, we agree with the general spirit of Klee's proposal to tackle the astrophysical numbers "head-on". However, we believe we have shown that it is not clear that Klee himself has demonstrated his case against anthropic reasoning with respect to the astrophysical data. Indeed, we believe that in several places Klee may be hoisted on his own petard: the sharp practice. In this section we propose to examine Klee's thesis from a different angle. Specifically, let us grant that Klee has shown that some of the astrophysical numbers are not of such "fantastic precision" as has been advertised by some proponents of anthropic reasoning and ask: Does it follow that

the design argument is refuted? We will construct a reply on behalf of the theist to show that Klee's result does not refute the design argument.

We should pause here to note that it might be thought that there is a certain irony in the fact we must construct (almost from scratch) a rejoinder on behalf of the theist, (even though it is a position that we ultimately reject), given the intense scrutiny that anthropic reasoning has received in some quarters. Surely, it might be thought, the issue must have already been discussed. The explanation here is actually quite simple: the intelligent design agenda is actually a fringe in anthropic thinking. So it is with a wry smile that one should read the opening statement of Klee's abstract: "Recent developments in astrophysical cosmology have revived support for the design argument among a growing clique of astrophysicists." (p. 331) However, in the subsequent discourse there is not a single astrophysicist which is *unequivocally* cited as supporting the design argument (with the possible exception of the late Sir Fred Hoyle)[3], not to mention any "clique," and especially "growing clique". One would expect the author to support his allegations with more specific names and statements. As *astrophysicists* associated in a rather vague manner with the design argument, we find only the names of Davies, Barrow, Press, Lightman, and Tipler.[4] All in all, the "growing clique" is rather thin, so it is no surprise that the burden falls to us of formulating what we shall call the 'sophisticated theist's' response.

3.1 The Sophisticated Theist's Response to Klee's Argument.

The unsophisticated theistic design argument is bedazzled by whole numbers much in the manner of the Ancient Pythagoreans. The sophisticated theist has a different take on both the astrophysical and theological data. We might imagine, then, the sophisticated theist arguing thus:

> *Unlike some theists, we are more than happy to grant that Klee is correct that the finely tuned numbers are not as finely tuned numerically as has been alleged. However, an appropriate appreciation of the relevant theology shows that Klee's assessment of the data does not support an anti-design argument conclusion. Indeed, we think a case can be made that this lack of precision should in fact be expected. Consider that God could have made the universe such that*

it is overwhelmingly obvious that there was a designer at work. For instance, God could have engraved or marked every stone, every animal, every plant, etc., with the word 'God™'. We can easily imagine scientific investigation eliminating any possibility of hoax, e.g., if radioactive dating revealed that the engraving on many rocks predates the evolution of life on this planet then we would have pretty solid evidence of a designer at work in our universe. Furthermore, we can imagine any number of ways of mathematically ordering the universe. Think about a very simple example, the Prime Number Universe: God could have made a rather gauche universe where every solar system is based on prime numbers, e.g., the number of planets in a solar system is always a prime number, and every planet has a prime number of moons where planets with larger orbits have a larger prime number of moons. To get a fix on this, imagine what God would have to do to make our solar system into a member of the Prime Number Universe: He might destroy the last two planets so that we have a prime number of seven in our solar system. Furthermore, he would have to add and subtract a few moons to yield the following pattern: Mercury would have two moons, Venus three, Earth five, Mars seven, Jupiter eleven, Saturn thirteen, Uranus seventeen. If modern astronomy (starting with Galileo) had discovered that our solar system had this prime number configuration it would be an obvious conjecture to think that this was the result of the work of some Grand Designer. Clearly then God has in his powers the ability to flaunt the fact that He designed the universe. But while this sort of obviously designed universe is within God's ability to make, God has moral reasons for not making the universe in this way. Specifically, God did not design the universe this way because He wanted to make the universe, where possible, ambiguous between a secular and theistic interpretation; so that we could freely choose to embrace Him or not, and that we may freely will to perform good or bad acts. As Murray argues (1999, p. 243)

> …it seems clear that fully robust and morally significant free will cannot be exercised by someone who is compelled by another in the context of a threat. …[I]f God does not remain "hidden" to a certain extent, at least some of the free creatures He creates would

be in the condition of being compelled in the context of a threat and, as a result, such creatures could not exercise their freedom in this robust, morally significant manner.

A universe that exhibited overwhelming design qualities would not allow any free choice in the matter of whether to believe in God, or whether to perform good or bad acts in the absence of a threat. So, it would have been improper for God, to make fine tunings "fantastically precise"—to use Klee's phrase—because then He would not have remained sufficiently "hidden". Thus, it is to somewhat oversimplified to claim that the absence of "fantastical precision" is an argument against the theist's assessment of the astrophysical data. The fact that the relevant numbers are pretty close to the conceivable optimum, although not exact, supports God's mission to create a somewhat ambiguous universe: God wants to lay clues to His existence but He does not want to make the evidence so overwhelming that it forces everyone to believe in Him. (On the other hand, He did not want to make the evidence against His existence overwhelming either). The fact that God has laid clues can be seen from the fact that it is pretty clear to all in the debate that the astrophysical numbers cannot be thought to be purely random.[5] *As Oberhummer et al. (2000, p. 90) argue ...a change of more than 0.5% in the strength of the strong interaction or more than 4% change in the strength of the Coulomb force would destroy either nearly all C or all O in every star. To this we can add parameters of our best physical theories (like the GUTs or the standard Big Bang models) are fine tuned (although perhaps not with "fantastic precision") in the sense that the universe would have been inhospitable to life if their values had been slightly different, e.g., no life seems imaginable if the universe had contained only a highly diluted hydrogen gas, or if it had recollapsed before the temperature anywhere had dropped below 10,000 K, which corresponds to early expansion speeds different from the actual for only (plus or minus) one part in* 10^{10}*. Likewise, the universe containing only black holes (and thus extremely inhospitable for anything remotely similar to life) is statistically more probable from the observed configuration of matter for a factor containing a stupendous double exponential (e.g., Penrose 1989). If the values of our universe had been set randomly we would almost certainly not have existed. So what possible explanation is there for the fact that the universe just*

happens to fall into this narrow range of values allowing for the development of life? It seems that the atheist cannot explain this other than by saying that it is a fortuitous fact about the universe. A much more plausible inference is that the universe has been created by a Designer, which explains the fine tuned (but "not-so-fantastically tuned") numbers we observe. That is, the numbers are tuned sufficiently to provide clues to God's existence, but not too fantastically precise as to make it overwhelmingly obvious that God is the designer of the universe.

3.2 Non-Theistic Uses of Anthropic Reasoning

The sophisticated theist's rebuttal here appears to leave naturalists with a rather unappealing dilemma: either we accept the theist's explanation for the anthropic data—that is, the data that says that the values for the fundamental constants of our universe fall into the very narrow range that is compatible with the existence of life—or we offer no explanation for this. The way out of this apparent dilemma is to realize that appeals to anthropic reasoning need not be theistic. As we noted above, theistic appropriations of anthropic reasoning constitute a minority: anthropic reasoning makes perfectly good sense from a naturalistic view. There are a significant number of scientists (and philosophers) who recognize validity and significance of the anthropic principle—but they do not see anything even remotely similar to the design argument in it! Unfortunately, Klee does not discuss such naturalistic appeals to anthropic reasoning. Now it may be thought that Klee's exculpation here is that for exegetical reasons he focused on only theistic versions of anthropic reasoning, because his ultimate target is the design argument. However, the reply on behalf of the sophisticated theist shows that his argument does not provide sufficient support for his skepticism about the design argument.

It is arguable that the core of the anthropic reasoning, as noticed by many physicists (like J. Richard Gott, Fred C. Adams, Andrei Linde, etc., in addition to those which Klee mentions), is in fact anti-teleological. It is easy to appreciate how such a conclusion might be reached. Naturalistic anthropic reasoning accepts the apparent fine-tuning of our cosmological domain as a puzzling empirical fact in need of an explanation. As we have said, the design hypothesis provides one *possible* (but not necessarily *plausible*) explanation. But anthropic reasoning, together with other advances in physics, provides an

alternative explanation: if there is an ensemble of universes—also called the *multiverse*—with a suitably varying range of properties (and current quantum cosmological models, like Linde's chaotic inflation (e.g. Linde, 1986, 1990), do suggest that that is the case), then one would naturally expect some of these universes to be just right for life. Even if such universes are in a small minority, because of an "observation selection effect"—the life-less universes, where the constants are "wrong" contain no observers and cannot be observed—such a theory can predict that we should observe precisely what we do in fact observe: a universe that *appears* to be reasonably fine tuned. This does not happen because the underlying theory is fine tuned, or incorporates anything *a priori* improbable (which is considered by some to be a hallmark of the design hypothesis), but because an observation selection effect guarantees that we observe a very atypical part of the whole of physical existence. In other words, embedding of atypical (or "finely tuned") region of the entire reality into the larger whole, gives a perfect anti-teleological and naturalistic explanation of our (a priori improbable) observations (this was emphasized by the great late Robert Nozick as his "principle of fecundity").[6] Physicists and astronomers have been familiar with the observational selection effect for a long time, some aspects of it (e.g., Malmquist bias in astronomy[7]) being the subject of studious and detailed mathematical modeling.

The question arises, if scientists have been aware of observational selection effects for so long, why has it suffered relative neglect in the philosophy of science? While not directly addressing this issue, Klee suggests a possible reason when he writes (p. 352):

> I believe it is a mistake to see any virtue in trying to construct formal Bayesian probability arguments in the present context. To his credit, Leslie does not do so. He formulates his argument as an abductive one in which the mathematical data on the allegedly fantastically narrow intervals of variance are not used in a technically formal way.

Klee here is referring to Leslie's theistic argument in *Universes* (Leslie, 1989). According to Klee, the problem with trying to formulate something stronger than Leslie's inference to the best explanation

argument is that there is an insurmountable problem arising from issues involving measurement scales. While we cannot explore the issue here (and Klee does not pursue it either) the basic complaint is that the interval of variance compatible with hydrocarbon life can be made to seem larger or smaller depending on one's measurement scale. So, according to Klee, because of this, there is no hope of quantifying the argument with greater precision, and thus, nothing stronger than an argument to the best explanation can be made. This in turn suggests that there is a limited amount that philosophers and scientists can do to clarify and quantify the argument. Whether this is ultimately so remains to be seen. An antidote for such pessimism can be found in Bostrom (2002) (which is not discussed by Klee). It points out immediately that cosmology is fundamentally incomplete without taking into account the necessary "anthropic bias": conditions we observe in fundamental physics, as well as in the universe at large, are atypical, and require an explanation. Furthermore, Bostrom has constructed a Bayesian argument precisely of the sort Klee says there is no virtue in formulating. If this line of argument can be maintained, then not only is Bostrom's approach to anthropic coincidences superior to Leslie's, but it offers a chance of obtaining solutions to many serious problems in the philosophy of cosmology and physics. The central piece of this approach is the Observation Equation (Bostrom, 2002, p. 173), which subsumes seemingly vague assumptions and observational selection criteria in full mathematical rigour. Moreover, the last chapter of Bostrom's monograph gives an example how the very same Bayesian apparatus can be applied to both astrophysical fine tunings and to such issues as traffic planning and the origin of the thermodynamical arrow of time. In any event, if something along the lines sketched by Bostrom is correct, then it points the way philosophers of science might pursue the question of anthropic coincidences in a naturalistic and rigorous manner.

To summarize, if the design hypothesis was the only way of explaining the astrophysical fine tuning, then by an inference to the best explanation, one could think that fine tuning lent support to that hypothesis. But in fact, naturalistic anthropic reasoning shows that there is another viable explanation for the puzzling phenomenon of fine tuning (the multiverse) grounded in useful and much-investigated physical ideas (namely those of inflation and quantum cosmology). It thus *decreases the amount of support that fine tuning could be thought to give to the design hypothesis*. Therefore, this line of anthropic reasoning is, in its effect, anti-teleological. Whether this view should ultimately triumph is a

large topic that cannot be explored further here. The point we want to make simply is that there is a potential rival explanatory theory, hence, we can reject the sophisticated theist's claim that the design argument is the only viable explanation for the apparent fine tuning of the visible universe.

Not only does the naturalistic version of anthropic reasoning force a re-evaluation of the design argument, it also forces a re-evaluation of many objections to anthropic reasoning in Klee's article. For instance, in the section entitled "The recalcitrant sloppiness of crud" we read, as a response to the Press and Lightman (1983) study: "But how can the details be considered abhorrent in this context? *design arguments are all about details* [italics in the original]" (p. 345). Well, design arguments might be about details, but this is irrelevant in the present case, since Press and Lightman did not intend to promote any design argument! And—in contradistinction to the design argument—*observation selection effects are not all about details*. They are just about probability measures, and any interval is as good as any other in obtaining weights in the parameter space. It is only the *interpretation* of these weights that decides whether we should be flabbergasted or just indifferent toward one value or another. The simple truth about "anthropic" fine tunings is that some are rather precise, others not so. There appears to be a great spread in this "finesse" of coincidences, further research should give us a better idea which ones require an appeal to an anthropic explanation.

3.3 On the Necessity of Klee's Argument

We have argued, on the one hand, that Klee's claim that the astrophysical data does not support the idea of "fantastic precision" in itself is insufficient to support his skepticism about the design argument; and on the other hand, that a proper appreciation of naturalistic anthropic reasoning can be used to undermine the putative explanatory power of the design hypothesis. But it may be wondered at this point how we can claim (as we did above) that Klee's argument is necessary for refuting the design argument. For if, as we argued, the theist and the atheist both have an explanation for "less than

fantastically precise fine-tunings", then how can Klee's argument add anything to the undermining of the design argument?

To answer this, we need attend first to an unfortunate confusion, on the part of both admirers and detractors of anthropic reasoning, that the idea that the Eddingtonian numerology is somehow essential for understanding the anthropic principle. One of the virtues of the historical part of Klee's paper is that one can see how these ideas developed independently. As Klee describes the history, Eddington's numerology takes historical precedence. The appeal to numerology turns on the idea that the fundamental constants of our universe are in some sort of "mysterious" or "occult" numerological relationships.[8] The anthropic principle asserts that the fine tuning of our universe for life depends on the fundamental constants of our universe falling into a rather narrow band. It is arguable whether Klee always keeps this distinction in mind, but then again, even the monograph of Barrow and Tipler (1986)—what Klee describes as the "Bible" of anthropic reasoning—is not entirely innocent either in keeping these ideas distinct. However, that these ideas are logically independent of one another should be obvious. The fact that different values of the fundamental constants and cosmological parameters would lead to a lifeless universe has nothing to do with alleged simple arithmetical relationships between those constants and parameters. Anthropic thinking follows from the former, but not from the latter. To run them together is to fall prey to an irony of historical development, namely, the accident that the anthropic principle was brought to light when, in 1961, Dicke demolished Dirac's large-number hypothesis. Obviously this should not lead anyone to think that there is a necessary relationship between the two. Surely we can imagine a universe that exhibits all sorts of Eddington numerology, but is inhospitable to life (imagine radiation levels too high to allow life to develop). Conversely, we can imagine a universe where the physical parameters are finely tuned for life, but the parameters themselves do not exhibit any Eddington numerology. Thus, any critique of Eddingtonian numerology leaves the anthropic principle unscathed; to claim otherwise is a *non sequitur*.

While these ideas are distinct, we can imagine possible universes where they are both true. Let us think of these as 'gratuitously fined tuned universes'. Gratuitously fined tuned universes are a proper subset of finely tuned universes: they are finely tuned for life and exhibit mathematical "orderliness" above and beyond what is required for life. As an example of a gratuitously fine tuned universe, think

again the idea of the Prime Number Universe. Recall that this is a universe much like our own with the exception that every solar system has been arranged to exhibit a certain amount of mathematical orderliness: there is always a prime number of planets and every planet has a prime number of moons. This universe is fine tuned in the sense that the fundamental constants fall into a narrow band which are hospitable to life, but the universe also exhibits excessive mathematical orderliness: there is no reason to suppose that, if this universe is like ours, then having a prime number of planets in every solar system and every planet having a prime number of moons is in any way necessary for life. The naturalist, we believe, must concede that a gratuitously fine tuned universe is one where the design argument may have greater explanatory power than its rivals. For now we are imaging two things requiring explanation: that the fundamental constants of the universe fall into a narrow band or parameter space necessary for life, and that the universe exhibits mathematical orderliness above and beyond the requirements for life. A naturalistic appeal to anthropic reasoning can explain the former, but not the latter. On the other hand, the theist could appeal to the aesthetic of the designer to explain the excessive mathematical orderliness of such a universe, and so would seem to offer a better explanation.[9]

So, the question of whether the design argument has superior explanatory power resolves to this: Is our universe gratuitously finely tuned? The answer, we believe, is no, and here is where we can invoke Klee's results. Klee should be read as showing that the astrophysical data does not support the idea that we live in a gratuitously fine tuned universe. Klee is convincing in his rejection of Eddington numerology, and that the astrophysical data does not reveal some sort of "fantastic precision". We have argued that at least some of the data supports the idea that the universe exhibits fine tuning (section 2.2 and 3.1), but we do not think that there is evidence that the universe is gratuitously fine tuned.

It should be emphasized that we take this to be an empirical matter: it may turn out to be true that the universe is gratuitously fine tuned. Imagine, for example, that advances in astronomy eventually reveal that every solar system except our own in the visible universe is as described in the Prime Number Universe. Presumably we might attribute the first such distant solar system with this pattern to mere randomness. But surely after finding that solar system after solar system exhibited a prime number pattern it might be reasonable to suppose that our universe was designed, and that the designer wanted to remain hidden until we had technically advanced to the point where we could make observations of

distant solar systems. Alternatively, perhaps advances in astrophysics will show that the fundamental constants have some sort of hidden numeric relation that cannot be explain simply as a requirement for the development for life. Surely it would be dogmatic to rule-out a priori such possibilities—but it would have to be evidence of this sort to support the hypothesis that the universe is gratuitously fine tuned.

4. Conclusions

Our major complaint against Klee is that he fails to see that a successful defence of a naturalistic worldview in cosmology may well be dependent upon appreciation of the anthropic observation-selection effects. If we wish to refute sophisticated design arguments, we need to show the way to reconcile the observed non-randomness with the a priori negligible size of the life-permissible subset of the parameter space. Fortunately, modern quantum cosmology, coupled with the anthropic reasoning, offers a perfectly sound avenue along which further research in both physics and philosophy may find the solution.

The case against the contemporary design argument in astrophysics might be summarized by offering the theist a dilemma: either the theist maintains that the universe is gratuitously fine tuned or the theist does not. If the former, then the theist must adduce evidence that our universe exhibits more than the fine tuning necessary for life, in addition, the data must support the idea that the universe is designed with some concern for mathematical orderliness. But Klee does a good job of summarizing evidence against this hypothesis. If the theist takes the latter horn of the dilemma, then any explanatory advantage evaporates, if we allow that atheists too have an explanation for the apparent fine-tuning of our universe (as was discussed in 3.2 above).

We wish to conclude by emphasizing once again that fine tuning is completely divorced from Eddingtonian numerology and other claims that the universe exhibits gratuitous mathematical ordering. There is no logical or physical (especially not causal) relationship between the two, except the historical one. Any numerology is a counsel of despair, particularly today, when we may be on the verge of the completely unified theory of the dynamics of matter in nature. To criticize the anthropic principle on the basis of weaknesses of naive numerological musings of the 1930s is about as appropriate as criticizing the concepts of modern chemistry on the basis of the flaws of the Ancient theory of matter consisting of

earth, air, fire, and water. The anthropic principle has been perhaps overly criticized in recent decades, and often on flimsy enough grounds. It is, probably, a high time and good opportunity (offered, among other things, by some of the recent physical and cosmological studies quoted above) to pause, to rethink, and try to reach a new and deeper level of discussion.

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[1] On occasion we will use the singular 'anthropic principle' although we acknowledge that this glosses over the fact that there are a number of different anthropic principles. See Chapter 3 of Bostrom (2002) for some discussion.

[2] Besides being unclear whence the values of astronomical values (planetary, stellar, galactic masses and radii, etc.) in Klee's article come. He goes into detail in quoting the source for the physical constants, but we are left in total darkness as to the source of astronomical values, where his errors are perhaps at least as numerous as of the anthropic theorists.

[3] Klee attempts to link the late Sir Fred Hoyle with the use of anthropic reasoning in support of the design argument. This may not be such a difficult task, since Hoyle's personality is so complex and multifaceted, and his erudite ideas and interests so numerous. Thus, it is not hard to fetch something for everybody in his huge opus. Interestingly enough, during the "great battle" of twentieth-century cosmology, Hoyle always wore the atheist's suit, and has attacked his Big Bang opponents for invoking a miraculous and unknowable "creation event" at the initial singularity. It seems that he did actually change his views subsequently, allowing for the theistic interpretation of the empirical findings of physics and astronomy, specifically he invoked a form of the design argument similar to the one Klee describes; but he did not attempt to hide it. Thus, he wrote in the most visible of all places, *Annual Reviews of Astronomy and Astrophysics* (Hoyle 1982): "Suppose you were a superintellect working through possibilities in polymer chemistry. Would you not be astonished that polymers based on the carbon atom turned out in your calculations to have the remarkable properties of the enzymes and other biomolecules? Would you not be bowled over in surprise to find that a living cell was a feasible construct? Would you not say to yourself, in whatever language supercalculating intellects use, "Some supercalculating intellect must have designed the properties of the carbon atom, otherwise the chance of my finding such an atom through the blind forces of nature would be less than 1 part in 10^{40000}." Of course you would, and if you were a sensible superintellect you would conclude that the carbon atom is a fix."

[4] Carr and Rees are, as mentioned above, explicitly exculpated, and the position of Klee on Carter, Dicke, and Wheeler remains unclear.

[5] The naturalistic explanations at this point usually invoke a deeper structure contained, presumably, within the currently-sought "Theory of Everything", which could be shown to be mathematically or logically necessary. We cannot enter this fascinating topic here.

[6] Nozick (1981). It is not beyond reason that such an understanding is present, for instance, in the passage quoted above from the summary of Oberhummer et al. (2000) article; note the locution "in our universe".

[7] The difference between the average absolute magnitudes of stars (or galaxies or any other similar sources) in magnitude-limited and distance-limited samples, discovered in 1920. by K. G. Malmquist.

[8] The naturalistic explanations at this point usually invoke a deeper structure contained, presumably, within the currently-sought "Theory of Everything", which could be shown to be mathematically or logically necessary. We cannot enter this fascinating topic here.

[9] Of course the sophisticated theist response above would lead us to ask why God allowed aesthetic considerations—the mathematical ordering of the solar systems—to trump the moral imperative to remain somewhat hidden.