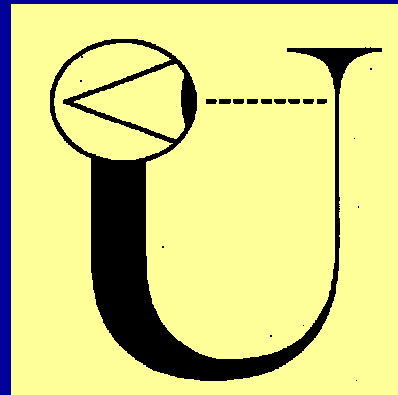


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Universe or Multiverse?

Some epistemological and metaphysical
considerations of modern cosmology



Tokyo, 2008

(1) Cosmological “**fine-tuning**” (FT):

- Modern cosmology, developed in the “standard model” of the beginning and evolution of the universe from a very dense and hot initial state (popularly called “Big Bang cosmology”), has by now collected enough evidence to maintain that our universe has been “fine-tuned” since tiny fractions of its first second.
- If the initial parameters had been just a little bit different, the particles of matter would not be such to enable complex structures (for example organic molecules), and so life could not have emerged. And worse still, without (FT) neither galaxies nor stars nor planets could have developed out of the primordial “fireball”.
- In many cases physical (FT) for life is independent of BB-cosmology, coming from other, well established branches of physics (for example, the difference between mass of a proton and a neutron etc.).



Picture, above: William Blake, *The Ancient of Days*, 1794, British Museum, London;
below: “*Deep Field*”, Hubble Space Telescope, 1996.

(2) Definition and criterion of “fine-tuning” (FT), following Robert Collins*:

- **Definition** of (FT):
“As a first approximation, we can think of the claim that a parameter of physics is ‘fine-tuned’ as the claim that the range of values, **r**, of the parameter that is life-permitting is very small compared with some non-arbitrarily chosen theoretically ‘possible’ range of values **R**. The degree of (FT) could then be defined as the ratio of the width of the life-permitting region to the comparison region.” (p. 179)
- Epistemological **criterion** of (FT):
“[T]he strength of a particular case of purported (FT) is primarily based on how secure the physical calculations or types of reasoning are behind the case of (FT) in question.” (p. 178)

Six “strongest” cases of (FT):

1. cosmological constant Λ (its actual smallness, compared with theoretical expectations)
2. ratio between the strong force and electromagnetic force (on which the stability of elements depends)
3. amount of carbon and oxygen production in stars (for the stability and long lives of stars)
4. proton vs. neutron mass difference (for the existence of stars *et al.*)
5. strength of the weak force (for the production of heavier than helium elements in stars)
6. strength of gravity (for the stability of 3D complex structures)

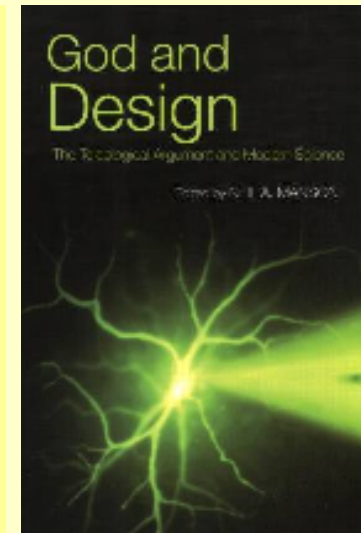
*Robert Collins, “Evidence for fine-tuning”, in: *God and Design. The Teleological Argument and Modern Science*, ed. Neil A. Manson, Routledge, London, 2003.

(3) Does the observed (FT) need **explanation**? Or is it due only to chance?

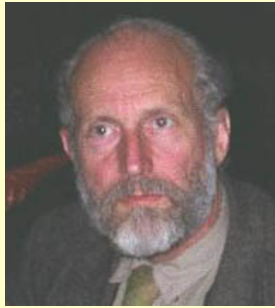
The intellect does not accept that such very very improbable coincidences “just happen” by chance – we have to explain them somehow.

So, in general we have three possible explanations:

1. The apparent (FT) might be scientifically explained in some future by the so-called “**Final Theory**” – however, the Theory which would explain all “free parameters” of physics is unlikely, at least for now.
2. The apparent (FT) can be explained by the “Observational Selection Effect” (OSE), expressed in the “**Anthropic Principle**” (AP) – however, this explanation has to be supported by the “Many-World Hypothesis” (MW-hyp), which postulates many other universes beside our universe (i.e., beside the Universe, evolved from “our” Big Bang); (MW-hyp) considers our universe only as a member of a vast “multiverse”.
3. The real (FT) can be argued with some variant of the “**Design Hypothesis**” (D-hyp) – however, this explanation is *eo ipso* teleological, and implicitly also theological, so that most “hard scientists” are not sympathetic with it. The (D-hyp) has, generally speaking, two possible ways to follow:
 - A. theistic (Designer’s transcendence beyond the universe; Demiurge, God)
 - B. pantheistic (immanent design *in* the universe, “self-organization” of nature).



These issues are discussed in a collection of philosophical essays *God and Design*, edited by Neil A. Manson (Routledge, London, 2003).



(4)

**Brandon Carter (1974):
the “Anthropic Principle”**

Brandon Carter: “Large Number Coincidences and the Anthropic Principle in Cosmology” (1974); publ. in: John Leslie (ed.): *Modern Cosmology & Philosophy*, Prometheus Books, New York, 1998, pp. 131-39.

Carter formulated (AP) in two versions:

- Weak Anthropic Principle (WAP) says:
“... that we must be prepared to take account of the fact that our location in the universe is *necessarily* privileged to the extent of being compatible with our existence as observers.” (*op. cit.*, p. 133)
- Strong Anthropic Principle (SAP) says:
“... that the Universe (and hence the fundamental parameters on which it depends) must be such as to admit the creation of observers within it at some stage. To paraphrase Descartes, ***Cogito ergo mundus talis est.***” (*ibid.*, p. 135)

Some proponents of (AP) emphasize the epistemological difference between (WAP) and (SAP), others deny it.

The preliminary Carter’s formulation of (WAP) is the following:

- “What we can expect to observe must be restricted by the conditions necessary for our presence as observers.” (*ibid.*, p. 132) = Observation Selection Effect (OSE).

(5) **John D. Barrow & Frank J. Tipler: *The Anthropic Cosmological Principle* (1986)**

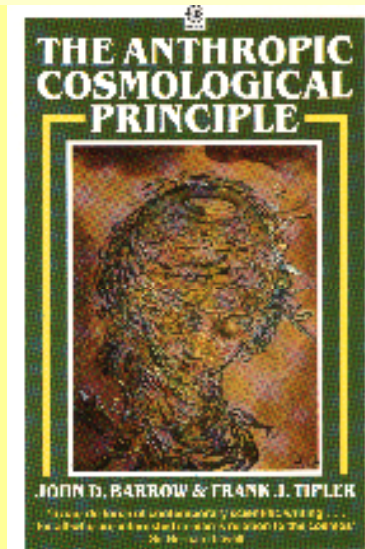
The question has been raised whether (WAP) has any explicative force at all – or is it just a tautology?

Barrow & Tipler argue in their seminal book that both versions of (AP) have many and important explicative applications in modern scientific cosmology. They demonstrate them with theoretical physics, the following example is clear intuitively as well:

- “No one should be surprised to find the Universe to be as large as it is. We could not exist in one that was significantly smaller. Moreover, the argument that the Universe should be teeming with civilisations on account of its vastness loses much of its persuasiveness: the Universe has to be as big as it is in order to support just one lonely outpost of life.” (B&T, p. 18, und. M.U.)

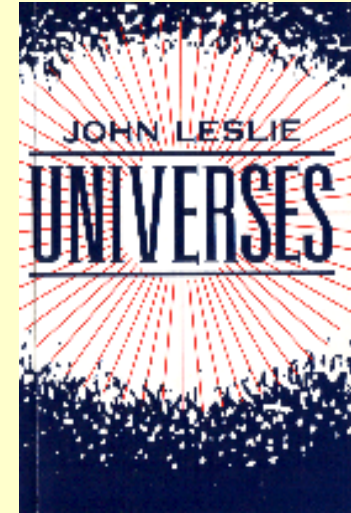
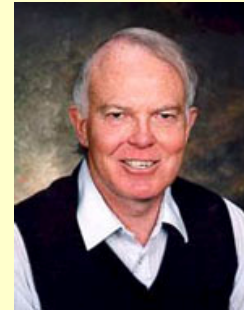
However, we must not forget that (AP) is not a law of physics (cosmology), but a meta-law, a methodological principle. (Of course we feel that something is missing in the above explication of the size of our universe.)

Barrow & Tipler interpreted (AP) as a teleological statement (but from Carter’s point of view, this is actually wrong), and their interpretation was quite influential for more than a decade.



(6) (AP) has explanatory power only if we presuppose **existence of many universes** (MW-hyp)

John Leslie, a British-Canadian philosopher, in his book *Universes* (1989) explained in detail that the “Observation Selection Effect” (OSE), which is inherent in both versions of (AP), works only in an existing “World Ensemble”, i.e. in the very large set of other *real* universes, hidden for our view.



$$\frac{(OSE) + (MW \text{ hyp})}{(AP)}$$

Leslie also points out:

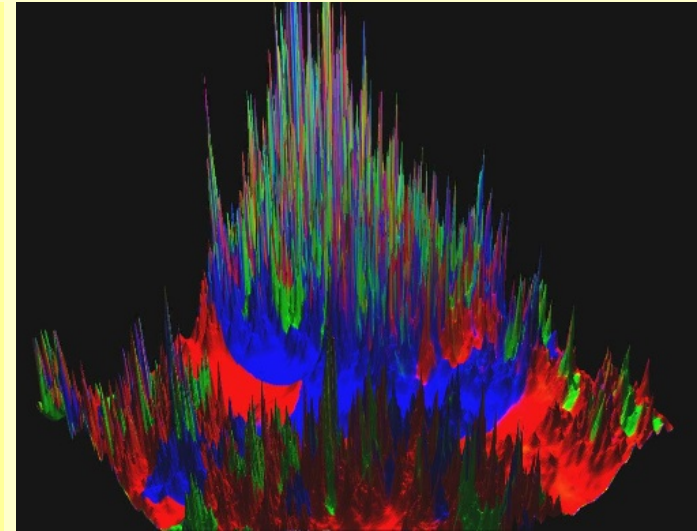
- that neither (WAP) nor (SAP) include teleological explanations (although they *may* be compatible with teleology), but give just *logical* reasons for fine-tuning of our universe;
- that there is no essential epistemological difference between (WAP) and (SAP), since the distinction is only ‘extensional’, i.e., it is only a question of how we define terms ‘location’, ‘region’ (or ‘domain’) and ‘universe’.

To avoid terminological confusion, I propose that we reserve the expression “the **Anthropic Principle**” (AP), namely in both variants, for the original, non-teleological Carter’s formulation, and that we use the expression “the **Anthropic Reasoning**” (AR) for its extensions, possibly also teleological, compatible with “God’s Design” (D-hyp).

(7) But where do **many universes** come from? How are they “generated”?

Theoretically, there are several possible ‘scenarios’ available for the emergence of many universes:

1. universes (or regions of the Universe) are not causally connected because their past light-cones do not overlap (“classical” idea, following Einstein);
2. universes are separated in time because of cyclic repetitions of “big bangs” (early John Wheeler, recently modified by Steinhardt & Turok);
3. universes originate from different breakings of symmetries in the “eternal inflation” (Andrei Linde, Alexander Vilenkin, Martin Rees);
4. universes are evolving along parallel branches of the “cosmic wave function” (following “many-worlds” interpretation of quantum physics: Hugh Everett, recently David Deutsch);
5. universes (as many as $\sim 10^{500}$) populate the “Cosmic Landscape”, derived from string-theories (Leonard Susskind, Steven Weinberg ...).



Andrei Linde’s “Landscape of Eternal Inflation” (from *Discover* magazine, online)

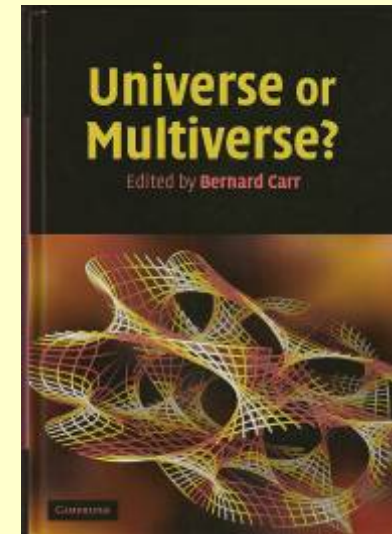
(8) **Max Tegmark**, “The Multiverse Hierarchy” (2003, reprinted in *Universe or Multiverse?*)

“... theories of physics involving what are termed ‘parallel universes’ or ‘multiverses’. These form a four-level hierarchy, allowing progressively greater diversity:

- **Level I** A generic prediction of cosmological inflation is an infinite ‘ergodic’ space, which contains Hubble volumes realizing all initial conditions – including one with an identical copy of you about $10^{10^{29}}$ meters away.
- **Level II** Given the *fundamental* laws of physics that physicists one day hope to capture with equations on a T-shirt, different regions of space can exhibit different effective laws of physics (physical constants, dimensionality, particle content, etc.), corresponding to different local minima in a landscape of possibilities.
- **Level III** In unitary quantum mechanics, other branches of the wave-function add nothing qualitatively new, which is ironic given that this level has historically been the most controversial.
- **Level IV** Other mathematical structures give different fundamental equations of physics for that T-shirt.

The key question is therefore not *whether* there is a multiverse (since Level I is the rather uncontroversial cosmological concordance model), but rather *how many* levels it has.”

(*Universe or Multiverse?*, pp. 99-100, underlined by M. U.)



A comprehensive, interdisciplinary collection of essays about “multiverse”, edited by Bernard Carr (Cambridge Univ. Press, 2007).

(9) Do we have any empirical evidence that *some* other universe exists?

Strictly speaking, we do not have such evidence, since all we empirically know in cosmology (red shifts, background radiation etc.), comes from *our* Universe.

However, some proposals how other universes might be *indirectly* detected are discussed in recent cosmological research, in the “braneworld scenarios”:

- If our cosmic spacetime is a 3D-brane, “floating” in spacetimes with more dimensions (up to 10+1 in “M” string-theory), then photons are (following this theory) *open* strings, i.e. their endpoints are “glued” to our brane, so they – light – can not leave it, while gravitons, the presumed particles of gravitation, are *closed* strings with no endpoints and so not trapped within particular branes.
- This feature of gravitons might be empirically tested, in similarity with the “Kazimir’s effect” (decreasing of fluctuations between two metal plates – in the case of gravity, between two “parallel” 3D-branes), and the positive result of such an experiment could explain why gravitation is so weak in comparison with the other basic long-ranging force, electro-magnetic force.
- **Brian Green** writes: “Through the gravitational force, we could both influence and be influenced by extra dimensions. Gravity, in such a scenario, would provide our sole means for interacting beyond our three space dimensions.” (*The Fabric of the Cosmos*, 2004, p. 394).

If there are other physical dimensions, then the implication to at least *some* other universe(s) is more likely. However:

- Gravitons have *not* been discovered yet, and M-theory is still hypothetical.
- The step from the discovery of other spacetime dimensions and/or *some* other universe(s) to a vast “Landscape” of multiverses, outlined by Leonard Susskind, Max Tegmark *et al.*, is still *very* speculative.

(10) Is a statistical verification or (at least) falsification of (MW-hyp) possible?

- Some well-known cosmologists who support (MW-hyp), for example Steven Weinberg, Martin Rees, Leonard Susskind, Don Page, Nick Bostrom *et al.*, think that multiverse can be indirectly tested by statistical methods, applied on available physical data.
- The most investigated parameter is the “cosmological constant” (Λ) which has its actual value $\sim 10^{120}$ times smaller as its theoretically expected value, and this is hardly just a “happy coincidence”. According to “anthropic reasoning” (AR) and statistical expectations (“normal distribution”), the actual value of Λ should *not* be very far below the highest value which still permits life – and this is actually the case.
- The point is that this statement might have been already statistically falsified – but it has not been by any relevant recent measurements.
- **Don N. Page** writes: “One objection that is often raised against the multiverse is that it is unobservable [...] but one can test a theory that makes use of unobservable entities to explain and predict the observable ones.”
(From: *Universe or Multiverse*, p. 412-13)



An old story of human curiosity ... looking for “unobservable entities” (a drawing from 15. century).

(11) The difficulty with definition of “observers”, the problem of “freak observers”

How high the “highest value which still permits life” (and/or observers) has to be posed is obviously determined by the definition – domain – of possible “observers”.

- Here, such questions are raised: Must conscious observers be made of carbonic molecules? Answer: Presumably not. However, must they be made of fermions (particles of matter), not only of bosons (particles of energy)? Answer: Probably yes, at least from the scientific point of view (by putting out of this debate angels etc.).

Namely, if the domain of possible observers is too large, than almost anything (every value of physical parameters etc.) can be explained by (AR), so it is of no use.

- But even if we restrict the domain of “observers”, let us say to the carbon-based life, another question remains: Are so-called “freak observers” (“naked brains” etc.) more numerous in our restricted domain as “normal observers” (humans, “humanoid aliens” etc.)?

In order to avoid this “freaky” problem, the “Principle of Mediocrity” (PM) was suggested by **Garriga & Vilenkin** (2003), which requires that “our civilization is typical in the ensemble of all civilizations in the universe” (see: *Universe or Multiverse?*, p. 345). – If this sounds too speculative, another variant of (PM) may be suggested, the “Self-Sampling Assumption” of **Nick Bostrom**:

(SSA): “One should reason as if one were a random sample from the set of all observers in one’s reference class.” (Bostrom, *Anthropic Bias*, 2002, p. 57, underlined by M.U.).

- By (SSA), which is a more sophisticated variant of the already mentioned “Observational Selection Effect” (OSE), “freak observers” are excluded from the statistically relevant part of the domain of all possible observers.

(12) Conceptual, set-theoretical problems with (MW-hyp)

Some of the best recent epistemological contributions to the cosmological (MW-hyp) problem, (George Ellis, Lee Smolin, Anthony Aguirre *et al.*, see: *Universe or Multiverse?*), use set-theoretical methods for description and analysis of multiverse(s).

W. **Stoeger** & G. **Ellis** & U. **Kirchner** in their interesting paper *Multiverses and Cosmology: Philosophical Issues* (2006) point out that we have at first to define the set ***M*** of all possible universes *m*, then the distribution function $f(m)$ which selects within ***M*** the actual universes, and finally the criterion (also function) which determines the “anthropic” subset within the latter. But difficulties in doing that are severe:

- “When speaking of multiverses or ensembles of universes – possible or realised – the issue of infinity inevitably crops up. Researchers often envision an *infinite* set of universes, in which all possibilities are realised. Can there be an infinite set of really existing universes? We suggest that the answer may very well be ‘No’.” (S&E&K, p. 13).

The main trouble here is that some variants of the well-known set-theoretical paradoxes (Russell’s paradox, Burali-Forti’s paradox of the largest ordinal etc.) sneak into cosmological multiverse-models: What should we say about the existence of the “Multiverse of *all* universes”? Is there the ultimate, “absolute” **Universe**?

The similar basic problem may be raised concerning the natural laws for set(s) of universes: Are there the ultimate, “absolute” Laws of nature? If the answer is yes, what kind of laws are these Meta-Laws: mathematical, logical, metaphysical ...?

From this “ultimate” point of view, the classical philosophical insights of **Immanuel Kant** and **Georg Cantor** (and other great spirits of humanity), concerning the limits of knowledge, are still very relevant and illuminative for contemporary cosmology.

(13) So – after considering the difficulties of (MW-hyp) – is the theological “Design Hypothesis” (D-hyp) the best possible answer to the question of cosmological “fine tuning” (FT), after all?

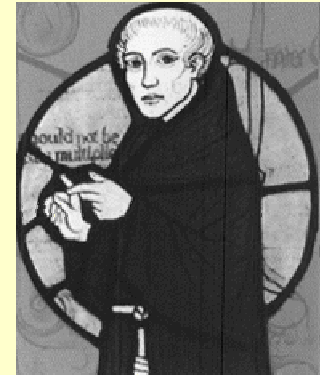
One of the main proponents of *theistic* (D-hyp), English philosopher **Richard Swinburne** criticizes the (MW-hyp), appealing to the “Ockham’s razor”:

- “Many-worlds interpretation is like an enormous inverted pyramid of theory resting on a vertex of observation. [...] The existence of God is much more likely on the evidence of our life-producing world than the existence of ‘many worlds’.” (From: Leslie J., ed.: *Modern Cosmology. & Phylosophy*, 1998, p. 178, underlined by M.U.)

In principle, I agree with Swinburne’s critique of (MW-hyp) – however, the following question remains: Is the only alternative to (MW-hyp) the existence of God as a Designer?

Namely, the theistic solution of the problem is convincing only to those who believe in a personal God as a Creator of the Universe. It is not a scientific answer.

That’s why I prefer the search of some “pantheistic” version of (D-hyp), closer to science; a version of an always “creative Deity”, immanent in nature, *Logos in Cosmos*, following (in this respect) **Baruch de Spinoza**: *Deus sive natura* (“God or nature”).



William Ockham
(1285-1347)



Baruch Spinoza
(1632-1677)

(14) In searching the “**third way**” between atheistic (MW-hyp) and theistic (D-hyp), I have found an interesting and promising approach in the philosophical cosmology of **Paul Davies**

The **relevance of mind in cosmological investigations**:

- “I have come to the point of view that mind – i.e., conscious awareness of the world – is not meaningless and incidental quirk of nature, but an absolutely fundamental facet of reality. That is not to say that we are the purpose for which the universe exists. Far from it. I do, however, believe that we human beings are built into the scheme of things in a very basic way.” (From *The Mind of God. Science and the Search for Ultimate Meaning*, 1992, p. 16, underlined by M.U.).

Following the idea of “the participatory universe” by John Wheeler, Davies writes of “**the self-synthesizing universe**” the following:

- “The third answer, the one I have outlined, is that the universe has engineered its own self-awareness, through quantum backward causation or some other physical mechanism yet to be discovered. [...] Can the idea of the self-synthesizing universe go beyond the issue of why the universe is bio-friendly and illuminate the question of why the universe exists at all?” (From *The Goldilocks Enigma. Why is the Universe just right for life?*, 2006, p. 283, underlined by M.U.).



“The impression of design is overwhelming.”
(Paul Davies, from *The Cosmic Blueprint*)

“We are truly meant to be here.”
(*The Mind of God*, last sentence)



Conclusion: Mind has returned into scientific cosmological theories

The philosophical, *epistemological* analysis of the widely observed phenomenon that the principal cosmological parameters are “fine-tuned” for the emergence of complex structures, life and mind, reveals that *it is necessary to consider observer’s role in modern scientific cosmology* (also by analogy with quantum physics).

Whether the relevance of observers in cosmology implies that a *conscious mind* (or the Mind) is essential in the development of cosmos is still an open question – we have outlined three main ways to answer it – but anyway, the door has been opened for *a new cosmological approach to investigate relations between mind and nature*.

The “third way” hypothesis, the philosophical idea of a “self-forming universe”, has to be (and I am sure it will be) further investigated also from the scientific, physical point of view. *Philosophy and science have to collaborate* as much as possible in our common search to solve at least some “cosmic enigmas”.

Thank you for your attention!

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