Some Comments on Cosmological Natural Selection

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Preamble

Metaphysics for whom?

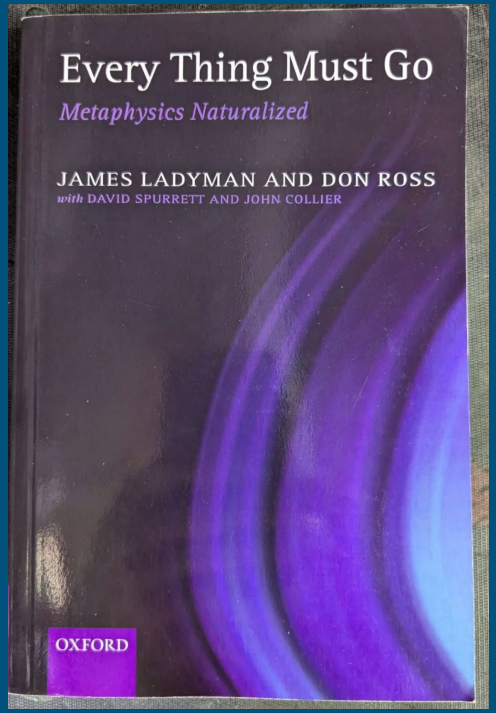
It’s hard to agree on exactly what metaphysics is

- Aristotle: “beyond” physics
- Kant: the law of causation as an *a priori* synthetic judgement
- The Logical Empiricists: metaphysics is nonsense to be excised from philosophy and science
- Modern physics: bring your own baggage!

Naturalized Metaphysics

Insofar as metaphysics bears upon physics, it **must not** contradict it:

> “The only kind of metaphysics that can contribute to objective knowledge is one based specifically on contemporary science as it really is, and not on philosophers' *a priori* intuitions, common sense, or simplifications of science.”
> —Ladyman and Ross



Outline

- The Fine Tuning Problem
- Anthropic Arguments
- CNS at a glance
- Cosmological objections to CNS
- Why choose CNS over Anthropic Arguments?
- Extra: Biological objections to CNS (if there’s time)

The Fine-Tuning Problem

Harrison, 1995

> “In a universe containing luminous stars and chemical elements essential for the existence of organic life, the physical constants are **necessarily precisely adjusted** (or fine-tuned). Slight deviations from the observed values could result in a starless and lifeless universe.” (p.193)

Harrison, Edward R (1995). “The Natural Selection of Universes Containing Intelligent Life”. In: Quarterly Journal of the Royal Astronomical Society 36, p. 193.

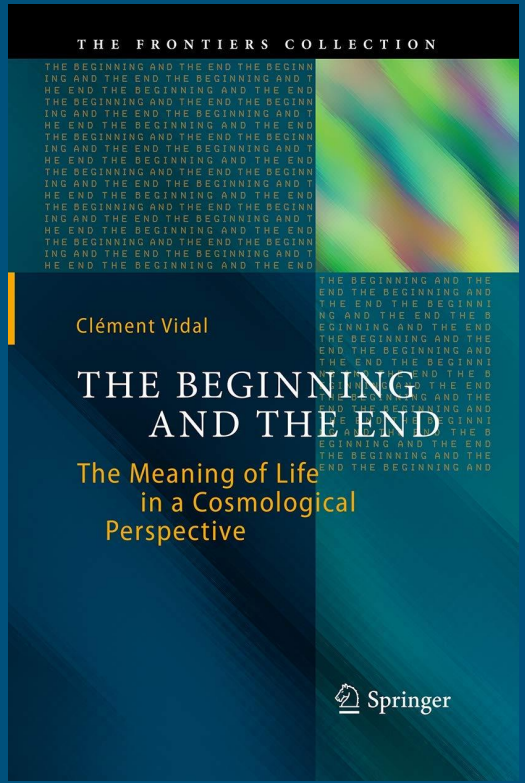
Gardner, 2014

"There is growing interest in the idea that the universe appears as if it has been fine-tuned. The standard model of physics rests upon ~30 dimensionless parameters that take seemingly arbitrary values that vary over many orders of magnitude. The physicists' model **gives no indication** as to why the parameters take their particular values, but it is widely agreed that if they took even slightly different values the universe would look strikingly different." (p.212)

Gardner, Andy (2014). "Life, the Universe and Everything". In: Biology & Philosophy 29.2, pp. 207–215.

Fine-tuning Issues

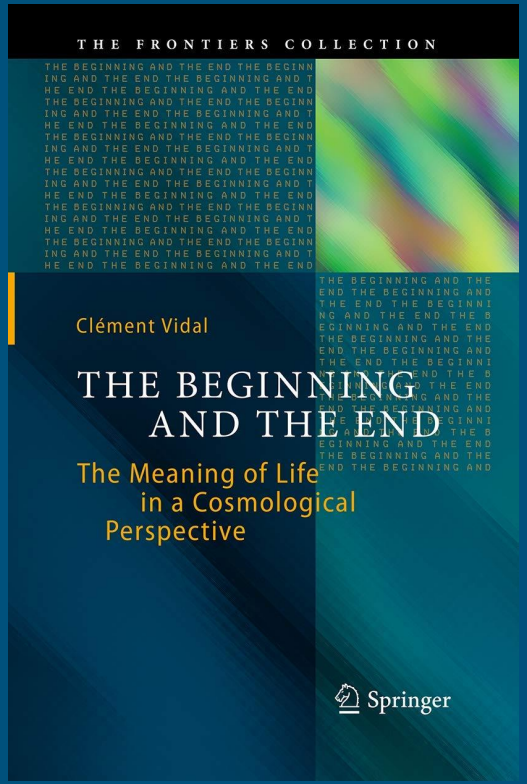
“The large literature shows a wide diversity of mutually contradicting positions on fine-tuning. The issue stems from physics, but is often motivated by philosophical or theological agendas. We can find **skeptics** who insist that fine-tuning is impossible to define rigorously, physicists who maintain either that it is a **central issue** in theoretical physics or that there is no need for fine-tuning, and **natural theologians** who use fine-tuning arguments to infer the existence of God.” (p.97)



Fine-tuning Issues

To avoid the intellectual minefield of fine-tuning misunderstandings, Vidal identifies three issues participants in any debate must be aware of:

- The free parameters issue
- The cosmic outcomes issue
- The parameter sensitivity issue



Free Parameters Issue

Free parameters issue: There are free parameters in the standard model and in cosmological models, which in principle can be filled in with any number (Vidal, p.78)

Free Parameters Issue

Standard Model of Particle Physics:

- Gauge couplings: 3
- Quark and lepton masses: 9
- Neutrino masses: 3
- CKM mixing angles: 3
- CP-violating phase: 1
- Higgs sector: 2

Total: 21

Concordance Model of Cosmology:

- Primordial fluctuations: 2
- Density parameters: 6
- Reionization: 1
- Hubble parameter: 1

Total: 10

We have ~31 parameter values we have to put in by hand!

Cosmic Outcomes Issue

Cosmic outcomes issue: What are the cosmic outcomes? What are the milestones of cosmic evolution? What parameters differentiate possible universe? How do we find those parameters? (Vidal, p.115)

Cosmic Outcomes Issue

Harrison suggests that, depending on the adjusted values that the free dimensionless parameters could take, we would end up with a universe in which no stars can form *and* life fails to emerge. However, nothing prevents the possibility of a choice of parameter values in which stars do form, but life fails to emerge, or a universe in which stars and life emerge, but the resulting lifeforms never attain sentience.

Cosmic Outcomes Issue

Unless one explicitly states which features of the observable Universe the parameters of physical theories are ostensibly fine-tuned for, disagreements about what a solution proposal to the fine-tuning issue should accomplish are bound to multiply.

Parameter Sensitivity Issue

Parameter sensitivity issue: Models of our universe display parameter sensitivity for some cosmic outcome *O*, when varying one parameter at a time

Parameter Sensitivity Issue

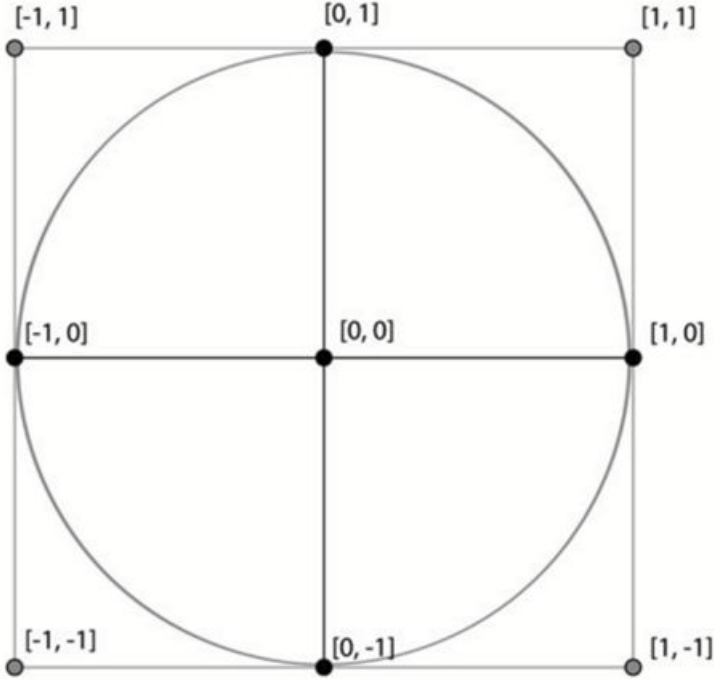
The One at a Time Fallacy:

According to Vidal, most papers on fine-tuning

> “use the OAT method to explore the space of alternative universes by varying each one of the 31 fundamental physics and cosmic parameters, and hence actually explore only r ~ 4.56E-15 of the parameter space" (Vidal, p.104)

The OAT Fallacy

Fig. 6.1 The one-factor-at-a-time method can only reach points on the cross. In this simple 2-dimensional parameter space, each discrete factor can only take values 0, 1, or −1. OAT can reach [0, 0], [0, 1], [0, −1] (points on the *vertical line*); and [−1, 0], [1, 0] (points on the *horizontal line*). But the corner points [−1, 1], [−1, −1], [1, 1], [1, −1] remain unexplored



Takeaways:

Concluding fine-tuning for a cosmic outcome *O* from parameter sensitivity is an invalid inference, especially when using OAT methods.

The phenomenon of parameter sensitivity in physical theories does not imply the the Universe is fine-tuned for life or intelligent observers like us

Varying multiple parameters at a time may weaken certain fine-tuning arguments (Stenger 2011)

Anthropic Arguments

Anthropic Arguments

The fine-tuned parameters of our best physical theories have precisely the numerical values needed to produce a life-bearing Universe endowed with observers capable of measuring their values because

- the Universe is the way it is with the fine-tuned parameter values we observe because otherwise, we would not have been able to ask this question in the first place (**weak anthropic principle**) OR
- were not for these specific parameter values, we would not exist (**strong anthropic principle**).

Vaas, Ruediger (June 2002). “Is there a Darwinian Evolution of the Cosmos? - Some Comments on Lee Smolin’s Theory of the Origin of Universes by Means of Natural Selection.”

Cosmological Natural Selection

Precursors

Pantin, Carl F.A. (1965). “Life and the Conditions of Existence”. In: Biology and Personality: A Symposium. Ed. by Ian T. Ramsey. Blackwell, pp. 83–105.

Wheeler, John A. (1977). “Genesis and Observership”. In: Foundational Problems in the Special Sciences. Ed. by Robert E. Butts and Jaakko Hintikka. Springer, pp. 3–33.

Hawking, Stephen W. (1987). “Quantum Coherence Down the Wormhole”. In: Physics Letters B 195.3, pp. 337–343.

Frolov, Valeri P., Moisey A. Markov, and Viatcheslav F. Mukhanov (1989). “Through a Black Hole into a New Universe?” In: Physics Letters B 216.3-4, pp. 272–276.

Smith, Quentin (1990). “A Natural Explanation of the Existence and Laws of Our Universe”. In: Australasian Journal of Philosophy 68.1, pp. 22–43.

CNS's Assumptions

1. Universes reproduce when black hole singularities bounce to become regions of spacetime

2. During the bounce, the excursions through a violent interlude at the Planck scale induces small random changes in the parameters of the effective field theories that govern physics before and after the transition (Smolin 2013, p.35)

In such a scenario, the **fitness measure** for a reproducing population of universes would be the number of black holes that each child universe begets.

Smolin, 2013. "A Perspective on the Landscape Problem". In: Foundations of Physics 43.1, pp. 21–45.

CNS is a Speculative Hypothesis

Admittedly, the role of black hole singularities as the reproductive mechanism for universes is one of the most speculative features of CNS, especially since bounce mechanisms are contentious.

Cosmological Objections

- The multiverse hypothesis is unscientific
- Even if there is a multiverse, bounce singularities yield causally disjointed space-time regions, which are unobservable
- Eternal inflation rules out big bounce singularities
- The laws of nature should be immutable
- …

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Do we need a Multiverse?

The Everett Interpretation, which is the *syntactically* simplest interpretation of quantum mechanics, implies the existence of a multiverse.

The *string theory landscape* postulates a multiverse of vacuum solutions where each point corresponds to a particular set of free parameter values.

> Upshot: talk of the multiverse may not belong to physics, but is certainly within the purview of **naturalized metaphysics**.

Do we need a Multiverse?

(Smolin 2013) admittedly draws inspiration from the concept of the biological fitness landscape. Each vacuum solution of string theory corresponds to a point in the string theory landscape with distinct values of the fundamental physics parameters in much the same way that each genotype in a biological population corresponds to a point in the fitness landscape.

Are the Laws of Nature immutable?

Before Darwin, species were considered timeless categories exempt from variation, most likely as a hold-back from the platonic theory of forms.

Darwin’s greatest success—and challenge—was to demonstrate that variation in organisms is the norm, not the exception.

Are the Laws of Nature immutable?

The situation in contemporary physics is similar to the pre-Darwinian state of affairs. The assumption that the laws of physics—supplemented by whatever fine-tuned parameter one posits—are themselves timeless categories is once more a remnant of Platonistic thinking, this time based on arguments about the unreasonable effectiveness of mathematics in explaining the natural world.

Are the Laws of Nature immutable?

Smolin draws on the work of Charles Sanders Peirce, an early adopter of Darwinism, to challenge the view that the laws of nature as platonistic:

> "Natural law is par excellence the thing that wants a reason such that the only possible way of accounting for the laws of nature, and for uniformity in general is to suppose them **results of evolution**." (Peirce 1891)

Peirce, Charles S. (1891). "The Architecture of Theories". In: The Monist 1.2, pp. 161–176.

Are the Laws of Nature immutable?

> “Peirce is saying that if we demand sufficient reason for the choice of laws of nature we can only answer successfully by positing that the present laws are the result of evolution from a past when the laws were different. To put Peirce’s argument in one line, ***Laws evolve to be explained***.” (Smolin 2013, p.26)

Upshot: The laws of nature are subject to intrinsic variation by means in fluctuations in the values of free parameters.

Why Choose CNS over Anthropic Arguments?

- CNS overcomes the platonistic prejudice of immutable laws
- CNS makes minimal assumptions about cosmic outcomes
- CNS circumvents the OAT fallacy by design

CNS requires less cosmic outcomes

“CNS explains why the Universe is tuned so that there are stars and carbon chemistry. This is the only explanation ever offered for this fact **that is not anthropic**, i.e., does not sue the existence of life as a part of the explanation.” (Smolin 2008, p.7)

Smolin, 2008. The Status of Cosmological Natural Selection. arXiV

CNS circumvents the OAT Fallacy

Since CNS focuses on the parameter values that optimize black hole production as those defining the reproductive success of a given child universe, it follows that CNS always varies multiple parameters at a time.

Extra: Biological Objections

CNS lacks a clear environment:

> Darwinian individuals engage in a *struggle for existence* against each other such that external factors constrain the spread of genes among a population, but CNS's universes are only limited internally by the number of black holes they produce. What, then, is the environment?

CNS lacks well-defined population concepts

> The Lewontin conditions for Darwinian evolution to occur demand variation, inheritance, and differential reproduction of individuals. Unless one furnishes CNS with such population concepts compliant with these criteria, biologists and philosophers of biology alike can deny that the theory is Darwinian in any meaningful way.