Multiversal Misgivings:

Negating the Naturalistic Universal Possibilism of Multiverse Cosmology

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Andromeda Galaxy: photo credit http://apod.nasa.gov/apod/ap061126.html

Physics and Metaphysics

- Metaphysical or worldview issues are *not* separable from the practice of science, nor should they be.
- Scientific "neutrality" is a myth; this much is *unavoidable*.
- There is a reciprocal relationship between metaphysics and physics.

The Fundamental Question

Is the ultimate explanatory principle of the universe to be found in *matter*, or in *mind*?

The Great Divide

THE PRIMACY OF MIND: THEISM

* The universe and has a transcendent intelligent cause
* The dependence and causal insufficiency of the material realm
* The universe and humanity have a purpose

THE PRIMACY OF MATTER: EVOLUTIONARY NATURALISM

* The self-sufficiency and causal closure of the material realm
* Strictly natural principles of development
* Absence of any universal significance

The Influence of Naturalism in Multiverse Cosmology

That evolutionary naturalism plays a strong role for some as a motivation for advocating the multiverse is quite clear. As Bernard Carr has summarized the situation:

"To the hard-line physicist, the multiverse may not be entirely respectable, but it is at least preferable to invoking a Creator. Indeed, anthropically inclined physicists like Susskind and Weinberg are attracted to the multiverse precisely because it seems to dispense with God as the explanation of cosmic design."

A Theistic Version of the Multiverse?

- The idea of a multiverse is *not* intrinsically incompatible with theism: it is certainly within God's power to have created more than one universe, and the proposed "mechanisms" of universe generation are themselves subject to rather tight design constraints.
- Nonetheless, these "mechanisms" also raise some peculiar theological issues in relation to Incarnational theology, soteriology and the metaphysics of personal identity given their reliance on the many worlds interpretation of quantum mechanics (quantum cosmology) and the unbounded redundancy of physical states of affairs brought about by chaotic eternal inflation.

No Factory Warranties from Multiverse, Inc.

- Furthermore, under the current hypotheses for randomized universal production, the other universes manufactured are overwhelmingly pointless:
  - Many recollapse quickly, fizzling into nothingness
  - Many are empty and devoid of matter and form
  - Many are chaotic monstrosities
  - Purposeful, ordered universes are a ***negligible*** fraction of the whole
- Our universe, on this view, would be an infinitesimal corner of purpose and light in the midst of infinite chaos and old night
- This is not the conception of an endless universe reflecting the glory of God. The metaphor of God as an Artist is sound, but His artistry is not the undirected chaos of a Jackson Pollock as these multiverse proposals would imply, but the focused brilliance and skill of a da Vinci or Michelangelo or Rembrandt.
- In short, current multiverse proposals are not testimonies to God's maximal greatness and inventiveness; insofar as they are coherent at all, they are testimonies to a blind role of the dice.

Should the Multiverse be Baptized?

- Arthur Holmes, retired philosophy professor from Wheaton College, famously stated that "*all* truth is God's truth."
- This was *not*, however, intended to be an avenue to baptizing whatever the current fad in scientific theorizing happens to be, but rather a statement that whatever is metaphysically the case, whether we recognize it or not, is so because God has either *made* it to be so, or *permitted* it to be so.
- In short, multiverse cosmology does not get a pass for baptism until it has successfully completed confirmation class.
- Given its atheistic cachet and theologically problematic status, passing confirmation class in this context would mean providing an explanation that is empirically and conceptually superior to that of first-order (as opposed to meta-level) intelligent cosmological design.

The *Dire Straits* Multiverse

- **Quantum Cosmology**
  - **Universes from nothing**
- **Chaotic Eternal Inflation**
  - **Initial conditions for free**
- **The String Landscape**
  - **Laws and constants on the MTV***

*Multiple Trials for Viability (with apologies to *Dire Straits*)

Examining Multiverse Explanations

In examining multiverse explanations we must consider five things:

1. The natural phenomena and assumptions motivating the strategy;
2. The proposed "mechanisms";
3. The assumptions governing these mechanisms and their operation;
4. An assessment of the strategy's explanatory power; and
5. The implications of accepting this mode of explanation for the nature and practice of science.

Quantum Cosmology:
Universes from Nothing?

Multiversal Beginnings

- All ***classical*** spacetimes have an absolute beginning, as shown by the Hawking-Penrose singularity theorems, and corroborated by Hubble expansion, the existence of the CMB radiation, and the conditions required for the nucleosynthesis of lightest elements.
- The **B**orde-**G**uth-**V**ilenkin (**BGV**) theorem shows that all ***inflationary*** spacetimes have a beginning in the finite past.
- If it exists, the multiverse had a beginning:
  - The ***string landscape model*** satisfies the BGV theorem
  - The aboriginal 3-branes in the ***cyclic ekpyrotic model*** (which is not inflationary) satisfy the BGV theorem
  - The primordial string perturbative vacuum in the ***pre-big bang inflationary model***, while exempt from BGV, is meta-stable throughout and therefore cannot be infinitely old.
- Many cosmologists insist that a "different physics" is required at the beginning: a "quantum nucleation event" of some sort requiring the resources of ***quantum cosmological description***.

A Quantum Free Lunch?

- It is a common-sense truth that whatever begins to exist has a cause, but some physicists appeal to acausal descriptions of quantum physics as evidence of the existence of *uncaused* material events.

- So it is that you find physicists like Frank Wilczek, Michio Kaku and Victor Stenger making extraordinary claims like "nothing, as a state, is *unstable*" and consequently the random appearance of things like universes are just one of those things that happen from time to time – with a quantifiable degree of *probability*, of course.

Prediction vs. Explanation in Quantum Physics (1)

- It's true that all quantum theories predict quantum tunneling – instantaneous jumps from one quantum state to another – for no discernible physical reason.
- Many quantum physicists have become so inured to such phenomena that they have arrived at the belief that some things in nature *happen without a cause and for no reason at all* – that we can predict what will take place with a certain probability, but if it does, *nothing caused it*!
- Quantum theories of physical phenomena provide *mere* mathematical descriptions that in many cases allow very precise predictions, *but provide absolutely no understanding of why or how such phenomena are possible*.

Prediction vs. Explanation in Quantum Physics (2)

- There is a difference, however, between *prediction* and *explanation*. A prediction tells you *what* will or may happen if certain conditions are satisfied; an explanation tells you *why* this is so.
- Quantum theories in physics provide mathematical *descriptions* that allow *predictions* of measurement outcomes to be made, but they *do not*, by themselves, *provide any explanation* for *why* the specific outcomes we observe have come about, or *how* they are even possible.

The Primary Metaphysical Lesson of Quantum Theory

- This situation worried Einstein and, as a consequence, he argued that the existence of nonlocal correlations in quantum mechanics showed that it was ***incomplete*** as a physical theory.
- Careful argumentation by John Bell and subsequent meticulous experimentation have shown that quantum theory is accurate, however. ***Einstein was wrong***.
- When the implications of such nonlocality are combined with those of various nonlocalizability results for unobserved quanta and the failure of identity and individuation criteria in quantum statistics exemplified, for example, by superpositions of particle number in quantum field theories, the proper conclusion is that ***incompleteness is not the property of quantum theory, but of physical reality itself. The universe and its operative principles are not causally self-sufficient, and therefore the universe itself is not causally closed!***
- The demonstrable absence of physical explanations for quantum events, however, do *not* mean that such events lack a cause, ***merely that whatever explains them is not physical in nature***.
- This carries with it a further, even more valuable lesson: ***evolutionary naturalism is false***.

"Fire in the Equations"

- In his book , *A Brief History of Time*, Stephen Hawking asks an insightful question that he does not answer: "What is it that breathes ***fire*** into the equations and makes a universe for them to describe?"
- As a matter of logic, mathematical descriptions may have metaphysical implications, but they do ***not*** function as efficient causes, either metaphysical or material. ***They are causally inert***.
- When quantum cosmology ***describes*** spacetimes as tunneling into existence from "nothingness" or from another other vacuum state, or relativistic quantum field theory ***describes*** matter as popping out of the quantum vacuum, ***neither provide an explanation, let alone an efficient cause, for such happenings***.

The Need for a Transcendent Cause

- The belief that such descriptions show that the universe does not have and does not need a cause is a ***non sequitur*** that runs counter to everything else we know.
- It is fair to say, then, that the demise of efficient material causality in fundamental physics and quantum cosmology reveals the ***limits of naturalistic explanation*** and the need for explanation in terms of a ***transcendent intelligent cause***; this is what rationality demands, and indeed, it is the only basis on which we should expect nature to be orderly and intelligible to the human intellect at all.

Shortcomings of the Hartle-Hawking Model (1)

- The model is, at best, a ***description***, not an explanation.
- It postulates an aboriginal state described by a highly structured mathematical space consisting of all curved 3-dimensional spaces, which, when matter is present, is extended to include the set of all pairings of curved 3-spaces and matter configurations on those spaces. This space is called ***superspace***.
- In the model, the ***quantum-gravitational wavefunction of the universe***, **Ψ**, does not "tunnel" into existence from "nothing," but into a constrained ***Lorentzian*** superspace from a highly-structured ***Euclidean*** superspace parametrized by an ***imaginary time*** coordinate. This process has ***no sufficient cause***, but is described by a suitably gerry-mandered probability distribution ***designed*** with the goal of rendering the geometry of our universe one of the most probable.
- Ψ must be ***constrained to oscillate in certain directions*** after it inexplicably "tunnels" into real time ***in order to establish as probable the right correlations*** between the curvature of space and the matter variables and their velocities.
- The postulation of Ψ ***assumes*** the existence of a coherent theory of quantum gravity, ***which we do not have***, and which, if we did, might not be amenable to these procedures.

Shortcomings of the Hartle-Hawking Model (2)

- The model, which employs the ***Feynman path integral formalism***, requires acceptance of the ***many-worlds interpretation*** of quantum mechanics, which is based on the idea that quantum wavefunctions never collapse; rather, ***every possible outcome of every quantum process is realized in actuality***, but each occurs in a different "***parallel universe***" empirically inaccessible to our own.
- Aside from the ontologically ***profligate***, ***untestable***, generally ***unwarranted*** and deeply implausible character of the many worlds "resolution" of the measurement problem, it also suffers from some ***intractable technical difficulties***: (1) it renders the ***unequal outcome probabilities*** of quantum theory ***unintelligible***, and (2) since there are ***infinitely many*** ways to decompose the quantum state of the universe into a ***superposition of orthogonal states***, the ***choice of decomposition*** and its accompanying ***ontology*** are completely ***arbitrary***.
- Euclideanization is a ***computational expedient*** used for constructing a convergent path integral; the suggestion that we should ***interpret it realistically*** as obviating an initial singularity and avoiding a universal beginning is ***disingenuous***. Transformation back into ***real time*** and a Lorentzian metric, which is ***necessary to describe the spacetime in which we live***, restores the ***singularity*** and an ***absolute beginning*** to the universe at which the ***laws of physics break down***.

A Final Admission

"The important point … is that … an observational test of quantum cosmology does not seem possible. Thus … sadly, ***quantum cosmology is not likely to become an observational science***."

- Alex Vilenkin (2002)

In short, quantum cosmology makes for a very bad bet.

Chaotic Eternal Inflation:

Initial Conditions for Free?

Inflationary Cosmology

Alan Guth introduced the hypothesis of cosmic inflation in an attempt to explain the "smoothing" of the universe's initial conditions by pushing the irregular values out *beyond the range of the observable universe*.

The smoothing/fine-tuning problems he had in mind were primarily the ***horizon problem*** (the uniformity of the cosmic microwave background radiation), the ***flatness problem*** (the ratio of the actual mass density of the universe to the critical mass density), and the ***absence of magnetic monopoles*** predicted by highly favored grand unified theories (GUTs).

Chaotic Eternal Inflation

Chaotic inflation is the idea that the initial "inflaton field" describing this process has very high energy that oscillates wildly and decays by a quantum process into innumerable local pockets each constitutive of a separate universe. **Eternal inflation** is the idea that this process goes on forever creating an endless number of universes that are causally isolated from each other.

Inflationary Cosmology Evaluated (1)

- Is inflationary cosmology as currently developed free from ***arbitrary assumptions***? *No*, it is not.
- ***First***, the scalar fields invented by inflationary cosmologists are ***ad hoc***, postulated merely to obviate the fine-tuning of initial conditions, and ***have no known connection to any other fields*** in physics .
- ***Secondly***, when an inflaton field is grafted onto the solution to the Einstein field equations most adequately describing our universe, as Stephen Hawking and Don Page have shown, while infinitely many models exhibit inflation, there are also infinitely many models that ***do not***. In short, there's ***no guarantee*** that inflaton fields, even if they were real, would do what they were invented to do.

Inflationary Cosmology Evaluated (2)

- ***Thirdly***, as Roger Penrose has argued, expansion from a ***generic*** singularity can become whatever kind of irregular universe we please, ***independent*** of whether there is an inflationary phase, so it is ***not*** an adequate explanation of the universe's flatness.
- ***Fourthly***, invoking inflation to explain why magnetic monopoles have yet to be observed deploys inflation as an ***ad hoc*** measure to ***spare*** favored yet ***unconfirmed*** grand unified theories from a ***failed prediction***. This does nothing to increase confidence in any of the theories in question.

Inflationary Cosmology Evaluated (3)

- ***Fifthly***, analysis of **WMAP** data has suggested a ***preferred direction for large scale modes*** of the CMB that disagrees with the uniformity predicted by inflation. If this anistropy holds up, not only will inflation's theoretical basis remain shaky, it will have ***failed*** experimental tests in its only real area of empirical traction.

- ***Sixthly***, the ***inflaton field*** has ***extraordinary fine-tuning problems of its own***. Let me explain.

Inflationary Cosmology Evaluated (4)

- The mechanism for bubble universe formation in inflationary cosmology is Einstein's equation in general relativity, which, even though it possesses ***no intrinsic connection*** to the inflaton field, is ***assumed*** to constrain the process of inflation in such a way that universe bubbles will form from local decay of the field while the field itself continues to fluctuate and expand.
- In the creation of these bubbles the inflaton field must be ***shut off*** and ***converted*** to normal mass-energy. This shut off point is ***delicate***, since the field is ***postulated*** to operate in the first **10^{-37} to 10^{-35} *seconds*** (or so) of the universe's existence, while causing space to ***expand by a factor of*** **10^{60}** (or so).
- The ***conversion*** from the inflation to the preheating era necessary to bring about particle production in an initially cold and empty universe involves a variety of ***highly speculative models*** with inflaton-preheating ***coupling parameters that have to be finessed*** to produce the right results.

Inflationary Cosmology Evaluated (5)

- Furthermore, depending on the inflationary model under consideration, ***the energy decay of the inflaton field also has to be fine-tuned to at least one part in*** 10^{53} ***and possibly as much as one part in*** 10^{123}.
- Compared to such levels of precision, the fine-tuning of the big bang inherent in the flatness problem (about 15 orders of magnitude) seems rather manageable.
- Finally, the ***massive fine-tuning problem*** associated with the low ***universal entropy*** needed at the big bang to produce a universe consistent with current observation is ***made exponentially worse*** by inflation.

Inflationary Cosmology Evaluated (6)

- The initial ***low entropy*** condition associated with the big bang at the beginning of our universe, which is required ***in order for thermodynamics as we know it to hold*** is extraordinarily fine-tuned.

- Roughly speaking, our universe had to ***come into existence with a very low measure of disorder*** so that the energy distributed among the particles of matter was available in a ***usable*** form.

- The crucial question, therefore, is: ***how special did the big bang have to be for the observed laws of thermodynamics to hold?***

Inflationary Cosmology Evaluated (7)

- Without going into the details of the calculation, which was done by Roger Penrose, to satisfy the observed entropy of *our* universe, the big bang explosion ***had to be fine-tuned to***:

  one part in $10^{10^{123}}$.

- The denominator of this number is difficult to grasp; suffice it to say that if we attached a zero to every proton and neutron in the observable universe, it would require $\mathbf{10^{43}}$ universes the size of our own ***just to write it out!***

Inflationary Cosmology Evaluated (8)

- The final point to be made, then, is that ***inflation makes this entropy problem exponentially worse***.
- As Penrose himself observes, if thermalization serves the role of driving background temperatures to equilibrium ***before*** inflation starts, then since inflation represents *an* ***exponential increase in entropy***, this requires the big bang to be ***even more finely tuned*** in order to account for its present value. In short, inflationary models require the universe to inflate ***into*** an entropy that is ***hyper-exponentially*** fine-tuned to one part in $10\exp(10^{123})$, ***requiring a pre-inflationary entropy that is hyper-hyper-exponentially fine-tuned***.
- On the other hand, ***if thermalization plays no role*** in resolving the problem of the uniformity of the CMB, then inflation is ***completely irrelevant*** to the solution of the problem for which it was invented!

The String Landscape:

Laws and Constants on the MTV?

What is String Theory?

- ***String Theory*** postulates that the fundamental constituents of nature are one-dimensional filaments, either open or closed into loops on the scale of the Planck length (10^{-33} cm), which ***vibrate*** in different ways to produce all manner of "particles."
- String theory is fundamentally a theory of ***gravity*** in ***10 dimensional spacetime*** with the extra 6 spatial dimensions "compactified" into Planck-scale topological constructs called "Calabi-Yau Spaces." There are an infinite number of ways of doing this.
- Compactification of the extra 6 dimensions ***transforms*** some of the ***gravitational modes*** in what would have been 9 large dimensions into a variety of ***non-gravitational*** bosonic and fermionic vibrations. It takes compactification of the ***gravitino*** – the supersymmetric partner of the ***hypothesized*** graviton – to produce spacetime fermionic matter (electrons, quarks, and such).

Some Other Notable Features

- Just what ***kind*** of non-gravitational forces and matter are produced by this transformation ***depends on the size and shape of the infinitely many ways of compactifying these extra dimensions*.**
- More specifically, string theory is postulated to provide us with a set of fundamental laws, but the ***shape*** of the associated Calabi-Yau space is supposed to determine ***which physical laws*** function in the 3 macroscopic dimensions, and the ***size*** of the compactified dimensions determines the ***strengths*** (universal coupling constants) ***of its forces***.
- It was originally hoped that a phenomenologically viable model of string theory (corresponding to the ***minimal supersymmetric standard model***) would be ***unique***. It is not. There are countless numbers of these as well.

The *Branes* Behind String Theory

- P-branes are spacetime objects that are solutions to Einstein's equations in the low-energy limit of string theory, where the energy density of the non-gravitational fields is *confined to some p-dimensional subspace* of the nine space dimensions in the theory. For example, in a solution with an electric charge, if the electromagnetic field were distributed along a *line* in space-time, this line would constitute a p-brane with p = 1.
- Branes come in discrete units, i.e., you'll never find a string solution with half a brane! Since branes also carry electric and magnetic charges, they give rise to discrete units of electric and magnetic flux.
- There is a special class of p-branes in string theory called *D-branes*. *All open strings must have their ends on a D-brane*, which makes a D-brane like a *collective excitation of strings*.

M-Theory

- When it was discovered that the five anomaly-free classes of superstring theories could be transformed to look like each other through mathematical transformations called *dualities*, it seemed a better conjecture that they were all a special case of a *more fundamental theory*, M-theory.
- These mathematical dualities connect quantities that were formerly thought to be separate. *Large and small distance scales* are related by so-called *T-dualities* and *strong and weak coupling (interaction) strengths* are related by so-called *S-dualities*.
- Such quantities have, until M-theory, always marked very distinct limits of behavior in physical systems, both in classical and quantum field theories.

String Theory: Is It *True*?

String theory has revealed a rich and fascinating world of mathematical relationships, ***but does it tell us anything at all about the reality in which we live****?* There are some significant reasons to doubt this:

- First, string theory doesn't make any ***unique*** predictions testable by current experiments – or currently ***conceivable*** experiments.
- Second, string theory comes in an ***unlimited*** number of versions. Even if we restrict ourselves to those gerrymandered to produce a positive cosmological constant, we still anywhere from $\mathbf{10^{500}}$ ***to*** $\mathbf{10^{1000}}$ ***distinct versions***.
- Third, nobody knows whether ***M-theory***, which is necessary to understanding the deep structure of string theory, is ***mathematically consistent***, that is, whether it avoids giving contradictory results and assigning infinite values to physical quantities. In short, ***we don't even know whether a complete and coherent framework exists*** that will unify the web of conjectures and approximations about strings into a tractable theory.

String Cosmology:
Exploring the Landscape

- Having at least 10^{500} string solutions was an embarrassment. ***Which of these stable vacua describes our universe? Why one compatible with life and not any other?*** *Does* our universe *really* have only a ***one in 10^{500}*** or even ***one in 10^{1000}*** probability of existence?
- Given this dismal situation, some string theorists decided to ***make a virtue out of this vice*** by helping themselves to *all* of these string-theoretic vacua in order to provide a naturalistic anthropic solution to the fine-tuning problem.
- The basic idea is that the spontaneous decay of ***meta-stable*** features ("moduli") of each string solution would allow it to ***spontaneously (acausally) quantum tunnel*** to another meta-stable inflationary string vacuum, and so on, until the whole "***landscape***" of string solutions was explored by this means.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (1)

- As we have already emphasized, the ***inflationary string landscape*** is subject to the BGV theorem and has an ***absolute beginning in the finite past*** and therefore a ***transcendent cause***.
- There is no reason intrinsic to the landscape that *necessitates* that it begin with a false vacuum energy greater than what we observe today – indeed, ***there is no necessity to the supposition that the universe started off in an inflationary state at all***, save that it gets the multiverse strategy off the ground.
- Nonetheless, it has been argued that, given the probability distribution of cosmological constants of ***possible*** universes over the ***whole landscape***, an order 1 cosmological constant is not an unreasonable assumption.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (2)

- It is vastly more likely in the landscape scenario that higher inflationary energy states ***cascade to lower ones***. The assumption of such a cascade is theoretically expedient for the purpose of anthropic explanations, but not guaranteed; there is, in principle, ***no way of knowing*** whether it is true.
- With the exponential suppression of transitions to higher energy states, the only way to ensure the entirety of the landscape gets explored is either to ***assume*** it starts in its highest possible energy state, or if in a low energy state, to ***assume*** that the first string vacuum that came into existence is exponentially older than today's Hubble time. Neither assumption is independently warranted.
- If it started off in a state of ***low enough vacuum energy***, however, the hypothesized landscape would have ***no relevance to the explanation of our finely-tuned cosmological constant***.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (3)

- Furthermore, there are reasons ***internal to string theory itself*** that ***cast doubt on the tenability of the landscape***.
- Michael Dine argues that if a string landscape of meta-stable ground states exists, it is likely to lead to a prediction of ***low energy supersymmetry***. But, he contends, in the landscape the parameters of low energy physics seem to be ***random*** numbers, and if this is true, the landscape is ***not*** a correct description of physics as we know it and so must be rejected.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (4)

- Susskind and Douglas think this criticism is very serious and do their best to counter it.
- Susskind argues, somewhat weakly, that the string landscape is unexplored territory and it is ***possible*** that it does ***not*** favor low energy supersymmetry.
- Douglas' argument is stronger and is based on an argument that models involving ***more than one independently distributed parameter*** lead to an expectation of ***high*** scale symmetry breaking.
- Since we do not yet have the mathematical wherewithal to provide a definitive answer to how the SUSY-breaking scale is distributed in a complete ensemble of ***phenomenologically viable vacua*** (i.e., those giving us the particles in the minimal supersymmetric standard model), the observations of Dine and others remain solid, ***casting doubt on the tenability of the landscape itself***.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (5)

- Finally, because the string landscape proposal assumes a mechanism of ***eternal inflation***, advocates claim there will be an ***unbounded number of instantiations of every possible string vacuum***.
- In consequence of this, it will also be maintained that in this scenario the highly precise initial conditions required by the ***Penrose calculation of universal entropy*** (**one in** $10^{10^{123}}$) will be ***instantiated an unbounded number of times***.
- This may seem a startling consequence, but in fact, some ***actual claims are much more extravagant***.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (6)

- Advocates of the eternally inflating string landscape typically maintain that there are ***infinitely many*** universes just like our own.
- Alex Vilenkin provides a good example, stating that:

> "In the worldview that has emerged from eternal inflation, our Earth and our civilization are anything but unique. Instead, *countless identical civilizations* are scattered in the infinite expansion of the cosmos." Indeed, clones of each one of us are endlessly produced throughout the inflationary landscape, for "*the existence of clones is… an inevitable consequence of the theory*."

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (7)

- The less enthusiastic among us might be inclined to remark that if it is a consequence of the theory that endless copies of ourselves exist holding every conceivable opinion and involved in every conceivable activity, then ***so much the worse for inflationary (string) cosmology***: it has successfully ***reduced itself to an absurdity***.
- Nonetheless, it is worthwhile to ask ***what the consequences of embracing this theory would be for science itself***.
- A fundamental implication of the theory is that every possible event, no matter ***how*** improbable will happen countless many times. Indeed, this conclusion has led to a flurry of strange articles by cosmologists discussing the string landscape in relation to ***Boltzmann Brains*** (BBs) and the question of our universe's ***typicality***.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (8)

- If, as inflation standardly ***assumes***, the de Sitter (dS) space in which our universe allegedly began is a thermal system, then a free floating BB can ***spontaneously appear*** in dS-space due to thermal fluctuations.
- Since quantum fluctuations into large volumes are vastly more improbable than fluctuations into small ones, the overwhelmingly most likely configuration would be the smallest fluctuation compatible with our awareness: a universe containing nothing more than a single brain with external sensations fed into it. ***Under standard conditions for bubble universe generation in the landscape, this problem becomes quite serious***.
- In fact, some calculations lead to free-floating BBs ***infinitely outnumbering normal brains***, in which case it becomes ***infinitely more likely*** that we ourselves are free-floating BBs rather than persons with a history living in an orderly universe several billion years old.
- The BB issue therefore ***suggests that the multiverse is falsified because the persons we take ourselves to be are not typical observers within it***.

Cosmological Fine-Tuning:
An Eternally Inflating Landscape Solution? (9)

- Needless to say, multiverse cosmologists find this conclusion rather disturbing and are trying to preclude it, ***but they cannot agree on how or whether progress is being made*** on the problem.
- One dominant approach is to find some measure by which our actual existence is *typical* in the multiverse and the superabundance of BBs is not, perhaps by ***finagling the decay time of the inflaton fields*** so that bubble universes don't get large enough to make BBs more likely than ordinary observers, or by introducing other *ad hoc* assumptions.
- While there is a sense in which ***anything*** with a non-zero probability of happening ***will*** happen – and an ***unbounded*** number of times at that – in an eternally inflating multiverse, a viable typicality condition would nonetheless have to ***privilege events that we take to be preconditions of our existence***.
- It is perhaps unsurprising then that we recently find the inflationary multiverse being invoked by a prominent molecular biologist, Eugene Koonin, ***as an "explanation" for the highly improbable origin of life***.
- It is not hard to see that such a strategy, were it to become a standard means of explaining improbable occurrences, ***would spell the end of science as a rational enterprise***. By providing an all-too-easy explanation for ***anything*** that has happened or may happen, the multiverse ends up explaining ***nothing*** at all.

Meltdown:
The End of Scientific Rationality?

Koonin and the Meltdown of "Scientific" Rationality

"***Despite considerable experimental and theoretical effort, no compelling scenarios currently exist for the origin of replication and translation, the key processes that together comprise the core of biological systems and the apparent pre-requisite of biological evolution***. The RNA World concept might offer the best chance for the resolution of this conundrum but so far cannot account for the emergence of an efficient RNA replicase or the translation system.

"The MWO [Many Worlds in One] version of the cosmological model of eternal inflation could suggest a way out of this conundrum because, ***in an infinite multiverse with a finite number of distinct macroscopic histories (each repeated an infinite number of times), emergence of even highly complex systems by chance is not just possible but inevitable***… Specifically, it becomes conceivable that the minimal requirement (the breakthrough stage) for the onset of biological evolution is a primitive coupled replication-translation system that ***emerged by chance***. That this extremely rare event occurred on earth and gave rise to life as we know it is ***explained by anthropic selection alone***….

"By showing that highly complex systems, actually, can emerge by chance and, moreover, are inevitable, if extremely rare, in the universe, the present model sidesteps the issue of irreducibility ***and leaves no room whatsoever for any form of intelligent design***."

- Eugene Koonin, molecular biologist, National Center for Biotechnology Information at the National Institutes of Health. "The cosmological model of eternal inflation and the transition from chance to biological evolution in the history of life." (http://www.biology-direct.com/content/2/1/15)

Susskind on Intelligent Design

Thus Susskind remarks:

"… If, for some unforeseen reason, the landscape turns out to be inconsistent – maybe for mathematical reasons, or because it disagrees with observation… [then] as things stand now we will be in a very awkward position. *Without any explanation of nature's fine-tunings we will be hard pressed to answer the ID critics*."

Leonard Susskind,
Felix Bloch Professor of Theoretical Physics
Stanford University

Quoted in *New Scientist* magazine,
December 17, 2005

Lewontin's Lament

- Having journeyed this far, we find ourselves back where we began, inquiring into the real motives behind certain attempts at "scientific" explanation.
- A helpful refresher is provided by another biologist, Richard Lewontin:

> Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. ***We take the side of science in spite of the patent absurdity of some of its constructs***, in spite of its failure to fulfill many of its extravagant promises of health and life, ***in spite of the tolerance of the scientific community for unsubstantiated just-so stories***, because we have a prior commitment, ***a commitment to materialism***. It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our a priori adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counter-intuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door. **The eminent Kant scholar Lewis Beck used to say that anyone who could believe in God could believe in anything. *To appeal to an omnipotent deity is to allow at any moment the regularities of nature may be ruptured, that miracles may happen*.**
>
> *- "Billions and billions of demons," The New York Review of Books, 9 January 1997: 28-32.*

The Ends of Naturalism

- Theism cannot be allowed because the regularities of nature may rupture and miracles may occur… what, like conscious brains popping out the quantum vacuum? Or even bigger things, perhaps even whole universes like our own?
- ***Who believes in miracles now****?*
- Following naturalistic explanation to its logical end has produced a universe in which ***anything can happen for no reason at all***.
- In the theistic universe, ***nothing happens without a reason***, and while nature is not self-sufficient and therefore not causally closed, ***any miracles*** constituted by intelligently directed deviations from divinely maintained regularities ***are also expressions of purpose***.
- What we have seen, then, is that ***the purposes of scientific naturalism cannot survive the purposelessness they create***, for out of the random void is birthed ***the end of scientific rationality itself***.

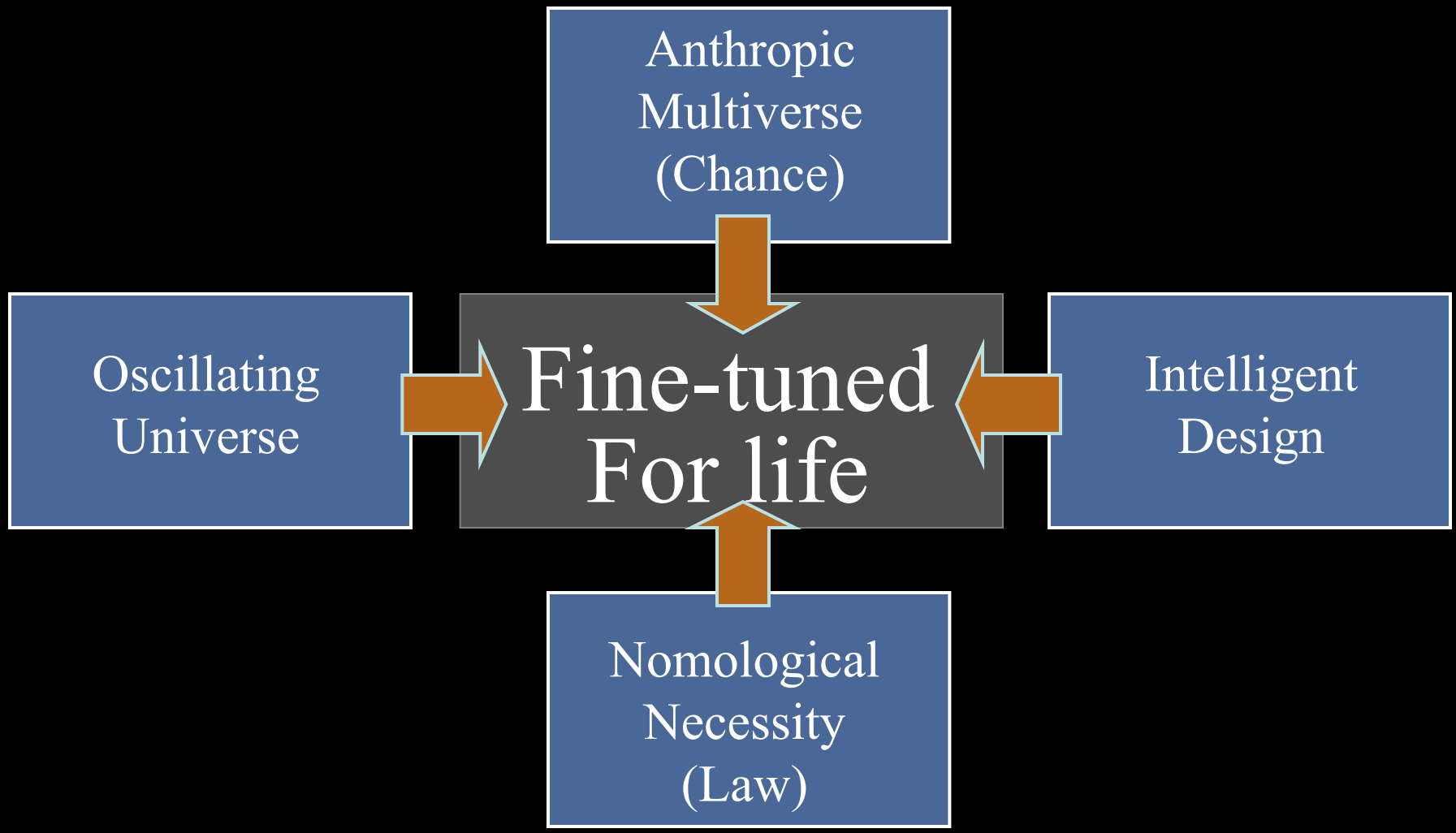
What Explains the Fine-Tuning, Then?

- As remarked earlier, since mathematical descriptions are causally inert, when *quantum cosmology* describes spacetimes as tunneling into existence from "nothingness" or from another other vacuum state, or *relativistic quantum field theory* describes matter as popping out of the quantum vacuum, *neither provide an explanation, let alone an efficient cause, for such happenings*.
- Rather than Leonard Susskind's "landscape of possibilities populated by a megaverse of actualities" providing a mindless solution to the problem of fine-tuning, then, *it completely ignores the fact that a virtually unlimited arena of mathematical possibilities cannot generate even one actual universe*.
- Furthermore, as Robin Collins and others have emphasized, a cosmological model that randomly varied the laws of nature in the universes it described *would itself have to be subject to lawful constraints were it not to break down*.
- In other words, the laws governing this process of variation would have to remain stable for the description to be coherent. Of course, were it to prove consistently realizable, this *carefully structured* variation process could quite plausibly be *an indication that the universe-generating mechanism* (M-theory?) *was designed for this purpose*… unless we embark on an *infinite regress* of such constructions.

The Metaphysical Verdict

- Given the logical and metaphysical *necessity* of an *efficient cause*, the demonstrable *absence of a material one*, and the conclusion that *there was an absolute beginning* to any universe or multiverse, the fact that our universe exists and its conditions are fine-tuned points inexorably toward *transcendent intelligent agency* as the causal factor of relevance.
- The *mindless* multiverse "solution" to the problem of fine-tuning *is a metaphysical non-starter*.

Multiple Competing Hypotheses



New Foundations or Old Ones?

Perhaps what is needed is not some new anthropic foundation for scientific cosmology, ***but rather a much older one***: the one that gave rise to modern science in the West and which, to this day, ***provides the only ontological and epistemic ground*** **on which we should expect nature to be intelligible to the human intellect**.

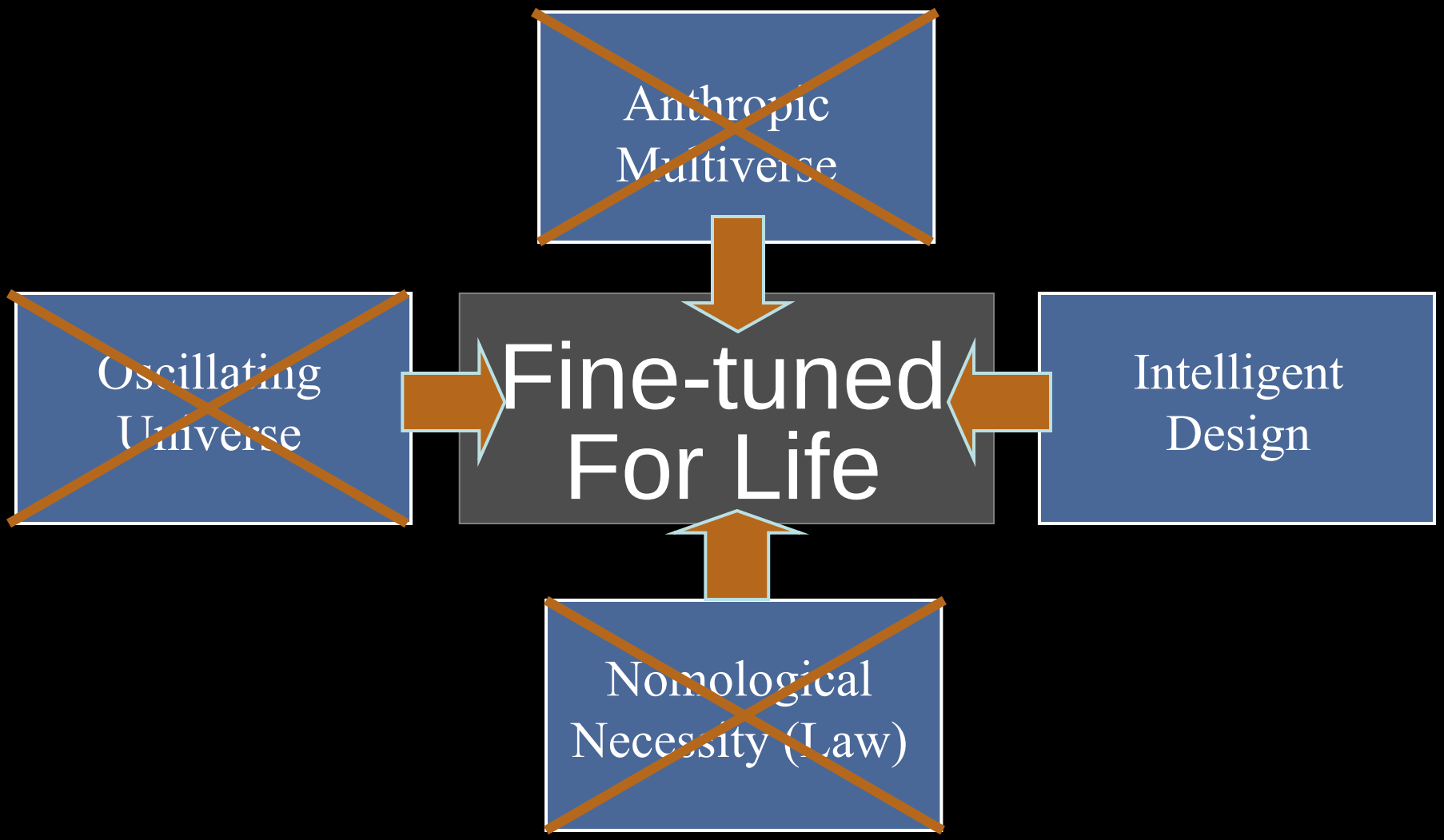
Small Specified Probabilities Imply Intelligent Design

- The ***correlation*** of (1) conditions that allow for ***life*** with (2) an ***extraordinarily fine-tuned*** range of values for the ***constants*** of nature and forms for the ***laws*** of nature, reveals a staggeringly ***improbable*** and ***meaningful*** coincidence which, in the ***demonstrable absence*** of a ***plausible*** material mechanism for its production, and the obvious ***causal sufficiency of intelligent agency*** for the phenomena in question, is most reasonably understood ***warranting a design inference***.

- Quite apart from the fact that the ***mindless*** multiverse hypothesis is a ***metaphysical non-starter***, we have seen the string multiverse is riddled with ***arbitrary assumptions***, ***special conditions*** and ***technical difficulties.*** The chaotic inflationary string multiverse proposal therefore ***does not adequately explain*** what we know to be true about the universe in which we live.

- In light of its causal adequacy to what needs to be explained, ***best explanation*** for what we observe and know is *intelligent causation*.

Multiple Competing Hypotheses



Intelligent Design and the Limits of Science

- So the fact that intelligent design can provide an evidence-based rational explanation for cosmological fine-tuning shows *either* the *limits of scientific explanation* and the need for a transcendent explanation, or the *need for an expanded conception of scientific explanation* that includes an inference to intelligent causation.
- As long as a willingness to follow the evidence where it leads is embraced, it doesn't ultimately matter whether the rational argumentation which gets us to the truth is called "scientific," *as long as withholding the appellation is not part of a disingenuous rhetorical strategy for deriding the conclusion and propping up an inferior explanation*.
- Truth, after all, must take the foremost, and affirming the best rational explanation available given the evidence – while recognizing this judgment is not separable from worldview issues – is what due epistemic diligence requires.

End Of Presentation

Appendices

M-Theory and the Cyclic Ekpyrotic Universe

The Cyclic Ekpyrotic Model

- Six of the seven extra spatial dimensions in M-Theoy are compactified throughout the bulk, so the effective picture that Steinhardt and Turok constructed is that of ***a bulk of four spatial dimensions existing between two 3-branes***.
- They calculated that these branes would establish a ***cycling pattern*** of gravitational attraction and bounce, with a time between ***collisions*** of about one trillion years.
- The collisions between the branes release enough energy to ***catalyze the hot big-bang stage of new universes***.
- Steinhardt and Turok estimate that on each cycle, the collisions have the potential to generate ***10^{100} and 10^{500} new big bang regions*** that are causally isolated from each other.

Cosmological Fine-Tuning:
A Cyclic Ekpyrotic Solution? (1)

- Steinhardt and Turok have shown that the phenomenological constraints on the scalar field potential in *cyclic ekpyrotic models* necessitate a *degree of fine-tuning* comparable to that of *inflationary models* – the number of degrees of freedom, the number of tunings, and the quantitative degree of tuning *are similar*. As our critique of inflationary cosmology has shown, this is *not really a point in favor* of the Steinhardt-Turok proposal.

- Lev Kofman, Andre Linde and others have argued that cyclic ekpyrotic models face *additional problems*. For instance, they argue that the Hořava-Witten version of string theory on which the ekpyrotic scenario is based requires the 3-brane of our universe to have positive tension, but the ekpyrotic model requires negative tension. To make the ekpyrotic scenario workable, therefore, the problem of the negative cosmological constant on the visible brane must be solved and the bulk brane potential *fine-tuned with an accuracy of* 10^{-50}.

Cosmological Fine-Tuning:
A Cyclic Ekpyrotic Solution? (2)

- Furthermore, to solve the homogeneity problem the ekpyrotic scenario would require the branes to be *parallel to each other* with an *accuracy of better than* 10^{-60} *on a scale* 10^{30} *times greater than the distance between the branes*.
- Steinhardt and Turok have alleviated some of these concerns with various gerrymandering assumptions, but significant fine-tuning issues remain.
- Veneziano and Bozza have shown that even a smooth bounce *cannot* generate a scale-invariant CMB density perturbation spectrum via the mode-mixing mechanism advocated by Steinhardt and Turok.
- Kim and Hwang have argued that it is *not even possible* to generate such a scale-invariant density spectrum using a bouncing model as long as the seed fluctuations arise (as proposed) from quantum fluctuations in the curvature perturbation of the branes in the collapsing phase – rather the spectrum resulting from such a process would be *significantly shifted toward the blue end of the spectrum*.

Cosmological Fine-Tuning:
A Cyclic Ekpyrotic Solution? (3)

- While Steinhardt and Turok *dislike anthropic reasoning*, seeing in it the *demise of rational scientific explanation*, with 10^{100} to 10^{500} new hot big bang universes generated on each cycle, it nonetheless can be asked whether the model can generate the probabilistic resources to explain the fine-tuning of Penrose entropy.
- It does not. It is *not* an inflationary model – though it does involve dark energy – so *it does not invoke an unending chaotic cascade of string vacua*.
- Rather, each trillion year cycle produces 10^{100} to 10^{500} big bang events with opportunities for finely-tuned entropy. This means that *with each new cycle* there is *at best a*

$$\mathbf{10^{500}/10^{10^{123}} = 10^{(500 - 10^{123})} \approx 10^{-10^{123}}}$$

  chance that the requisite entropy condition will be met.
- In short, the ekpyrotic universe would have to go through a significant fraction of $\mathbf{10^{10^{123}}}$ trillion year cycles for there to be any reasonable probability of getting a universe like ours. Given a *finite* history to the cycling stage and a *singular beginning* to the process, aside from the fact that there is *no way in principle* of determining how many cycles there might have been, the incomprehensibly large number of trillion-year cycles inspires *deep skepticism*.

Pre-Big Bang Inflation: The String Perturbative Vacuum Model

The Pre-Big Bang Inflation Picture

1. It begins with a ***meta*-stable *string perturbative vacuum (SPV) phase*** of ***potentially infinite*** duration in patches of which string-vacuum driven inflation eventually starts.

2. Under the right conditions this ***inflationary phase*** generates a ***hot-big bang*** of the sort that initiates universes like ours.

3. ***Somehow***, a ***graceful exit*** is made from the ***collapse*** in the classical Einstein-frame coordinates, ***leading to an FLRW metric*** characteristic of universes like our own.

Cosmological Fine-Tuning:
A PBBI-SPV Solution? (1)

- Pre-Big Bang string vacuum driven inflation of an SPV patch has to *last long enough* to reach a hot big bang nucleation event, but since the PBBI period is *tightly constrained* by the initial value of spatial curvature, this curvature has to be *extremely small* in string units if sufficient inflation is to be achieved to "solve" the flatness and horizon problems.
- Andre Linde and Rafael Bousso have also shown that the PBB inflation can only address the horizon and flatness problems if the primordial SPV is *extremely large and homogeneous* from the outset. In other words, the fine-tuning of our universe is "explained" *by pushing all the fine-tuning into the SPV era*.

Cosmological Fine-Tuning:
A PBBI-SPV Solution? (2)

- More specifically, if the PBB universe is *closed*, Linde and Bousso have shown that the SPV must consist of *at least* 10^{24} *causally disconnected regions of nearly equal density*. Needless to say, this is extremely improbable and is a *re-expression of the horizon problem* with a vengeance!
- On the other hand, if the PBB is *open*, then in order to account for the homogeneity of our universe, the SPV must start as an *unbounded* patch of flat (Minkowski) space with an *infinitesimally small* and *spatially homogeneous* string vacuum kinetic energy density of *infinite* extent.
- Even if this exquisitely fine-tuned homogeneity were explainable, Linde and Bousso also demonstrate that the possibility of resolving the flatness problem *depends on being able to explain the unlikely existence and value of two very large dimensionless and physically meaningless parameters on which this flatness depends*.

Cosmological Fine-Tuning:
A PBBI-SPV Solution? (3)

- Lastly, Linde and Bousso demonstrate that the dynamics of PBB cosmology *preclude the possibility of self-reproduction* and hence *do not lead to a period of eternal inflation* because quantum fluctuations during the inflationary stage are never large enough to overtake the rolling of the string vacuum field. As a consequence of this, the PBBI scenario has *no means of alleviating* the fine-tuning of its own initial conditions, let alone resources for addressing the one in $\mathbf{10^{10^{123}}}$ fine-tuning of the big bang entropy of our universe.
- Veneziano has suggested that this problem might be solved by the *regional contraction* of SPV patches of all different sizes to create big bang events. But the requisite fine-tuning that makes the contraction of any *one* patch unlikely makes the contraction of a significant fraction of $\mathbf{10^{10^{123}}}$ patches *hyper-exponentially unlikely*, and the *finite history* of the SPV phase further constrains such a scenario.
- In short, the PBBI model *does not have the probabilistic resources* necessary to explain away entropic or other kinds of cosmological fine-tuning.