God and the Multiverse

November 11, 2012. A Multiverse with a Beginning

St. John in the Wilderness
Introduction

Sessions

- **Nov 4**: Introduction. A Universe with a Beginning
- **Nov 11**: A Multiverse with a Beginning
- **Nov 18**: A Universe Finely Tuned for Life
- **Nov 25**: An Orderly, Rational, Comprehensible, Beautiful Universe. Conclusions.
Primary References

2. A Multiverse with a Beginning


Almighty and everlasting God, you made the universe with all its marvelous order, its atoms, worlds, and galaxies, and the infinite complexity of living creatures: Grant that, as we probe the mysteries of your creation, we may come to know you more truly, and more surely fulfill our role in your eternal purpose; in the name of Jesus Christ our Lord.
Introduction
Introduction

Goals

- To show how discoveries in modern astronomy and cosmology are:
  - compatible with a belief in a creator God,
  - can be most rationally explained by a creator God who deliberately created a universe — or multiverse — that would be fruitful of life.
Introduction

Week 1: A Universe with a Beginning

Observational cosmology has firmly established, from multiple lines of evidence, that our universe began 13.7 billion year ago in an event called “The Big Bang.”

The past is finite; there is a past limit to physical reality.
Introduction

Week 1: A Universe with a Beginning

- The Cosmological Argument for God (The “second way” of St. Thomas Aquinas, 1224-1274, based on the idea of causation):
  - 1. Everything we see in this world is caused.
  - 2. Nothing can be the cause of itself.
  - 3. There cannot be an infinite regress of causes – because the universe has a beginning. The past is finite.

Therefore:
  - 4. There must exist an uncaused first cause not of this world
  - 5. The word God means “uncaused first cause not of this world”.
  - 6. Therefore, God exists.
This Week: A Multiverse with a Beginning

- There is not a shred of observational evidence for any physical reality beyond the universe we see, the universe that began with the Big Bang.
- Therefore a Christian need look no further to declare that cosmology is fully compatible with God as the Creator.
- Furthermore, a Christian can quite rationally argue that the mystery of what caused “the Big Bang” is well explained by God as the Creator.
Introduction

This Week: A Multiverse with a Beginning

- There are however some physical theories:
  - some generally accepted theories (inflation theory) because they seem to explain important observations in this universe,
  - some unproven, often quite speculative theories (String theory / M-theory) held in high regard in the physics community because of what is hoped they will accomplish,

- that allow for (although do not require) “other” universes or “alternative” universes, not directly observable from our own – other universes:
  - that could have given rise to our own universe,
  - whose existence would mean “the Big Bang” was not truly the beginning of all of physical reality.
Introduction

*This Week: A Multiverse with a Beginning*

Our observable Universe

+ these unobservable “other” or “alternative universes”

= The “Multiverse”
Introduction

This Week: A Multiverse with a Beginning
Introduction

*This Week: A Multiverse with a Beginning*
Goals this week:

- Get a sense of where ideas of “the Multiverse” are coming from, how much is based on reasonable conjecture from known science, how much is pure speculation.
- Why even the “Multiverse” must ultimately have a beginning, and therefore require a “First Cause” which is outside / beyond / not of the Multiverse.
- Think about why God might choose to create a “multiverse” rather than a single “universe.”
Introduction

A Classification of Multiverses

- Multiverse which is a reasonable conjecture based on established theory:
  - Level I Multiverse = “Quilted” Multiverse

- Multiverses which are speculative conjectures based on incomplete and unproven theories:
  - Bouncing Multiverse
  - The Eternal or Chaotic Inflation Multiverse
  - The String / M-Theory Landscape Multiverse
  - Braneworld Cyclic Multiverse = Ekpyrotic Multiverse

- Multiverse which arises from the “Many Worlds” interpretation of Quantum Theory (we will not discussing this possibility today)
The Quilted Multiverse
Quilted Multiverse

The Observable Universe

- The speed of light limits how much of the universe we can see.
- Our universe began 13.7 billion years ago.
- Because of the on-going expansion of the space, a photon that has traveled for 13.7 billion years to reach us comes from a region of space that – at the moment the photon reaches us – has expanded to 42 billion light-years away from us.
- 42 billion-light years is thus the farthest away we can currently see, our “Cosmic Horizon,” our “Observable Universe.”
It is reasonable to expect the universe does not end at our “Cosmic Horizon,” but continues on.

These other unseen regions or domains or “quilts”, each (right now) with their own 42 billion light-year event horizon are considered other “universes.”

Together with our observable universe, they can be said to make up a “multiverse.”
“Quilts” near us should look very similar to our own universe.

Absent knowledge of conditions right at the “Big Bang,” and a theory of quantum gravity, we can say little about the “quilts” far distant from us.
Speculation can get fanciful if we imagine the quilted multiverse is infinite, with an infinite number of “quilts” that are all similar to ours.

Assuming:

- Limited number of particles in each quilt (hard to argue against)
- All properties of a particular particle (including position) are “granular,” and can assume only a limited, finite number of values (a dubious proposition)

Then all the possible ways of arranging the particles with all their possible properties is still a finite (albeit unimaginably enormous) number.
If there are an infinite number of quilts, and if all the possible ways of arranging the particles and all their possible properties is finite, then the “quilts” will start to repeat arrangements.

That is: we start to see “parallel” worlds (assuming specifying the arrangement and properties of all its component particles is enough to specify a world, a debatable proposition)

And if the number of quilts is infinite, the number of times an arrangement is repeated – the number of duplicate parallel worlds – would seem to also be infinite.
Infinite Earths in Parallel Universes Really Exist

Orphan Drugs: Too Successful?

Keys to Robust Networks

Smallpox Defense Readiness
This “parallel-worlds” scenario involves a lot of assumptions:

- Infinite extent of the multiverse.
- Each “quilt” of the multiverse basically the same as ours in composition (an astonishingly presumptuous extrapolation when taken to infinity)
- A “granularity” of all properties of the particles, allowing their complete state to be specified with perfect precision using just a finite amount of information.
Since the “Quilted Multiverse” arises from the Big Bang, it clearly has a beginning.
The Bouncing Multiverse
The fabric of the universe began expanding at the “Big Bang.”

If there is sufficient density of matter in the universe, the inexorable, continuous pull of gravity would slow the rate of expansion, until the expansion stopped and the fabric of the universe began to contract back down to a “Big Crunch.”
Speculative mechanisms have been devised that might allow the universe to then rebound or “bounce” back from the “Big Crunch” in another “Big Bang,” forming a new expanding universe.

- Cycles of
  - “Big Bang”
  - Expansion – contraction
  - “Big Crunch” – “Big Bounce”
  - “Big Bang”

- continue for eternity.
Bouncing Multiverse

The Big Bounce

- The generations of universes between bounces make up a “multiverse”
Bouncing Multiverse

Observational Problem

- This idea has big problems and is out of favor among cosmologists.

- Observational problem:
  - The expansion of the universe is *accelerating* because of the anti-gravity force **Dark Energy**, and it appears to the universe will expand forever.
Bouncing Multiverse

Theoretical Problems

- Theoretical problems:
  - Both Entropy (a measure of the amount of disorder) and radiation is inherited from the previous universe, and will continue to increase in each successive bouncing universe.
    - The universe would not be born “afresh” at each bounce, but would continue to age.
  - The increase in entropy and increase in radiation (“Tolman’s Limit) would cause the expansion-contraction cycles to lengthen, until eventually the universe would stop contracting, and just expanded forever.
    - The Bouncing Universe scenario thus cannot be “eternal.” It requires a beginning.
The Eternal or Chaotic Inflation Multiverse
We know the fabric of the universe is expanding at an accelerating rate ("inflating") by a mysterious anti-gravity force called "**Dark Energy**." Most cosmologists believe that an incredibly rapid expansion ("inflation") occurred in the early universe between $10^{-35}$ to $10^{-33}$ seconds after the Big Bang, driven by an anti-gravity force called the **Inflaton Field**. The energy of the inflaton field then transformed into a hot bath of particles and radiation expanding at much more sedate rate: our universe.
Eternal Inflation Multiverse

Inflation Theory

- Einstein’s General Theory of Relativity envisions space-time as a single flexible fabric that bends and quivers in response to the matter, energy and pressure it contains.

- The General Theory of Relativity allows for an “anti-gravity” force to be added to the equations.
  - The Inflaton field and Vacuum Energy (the leading hypothetical candidate for “Dark Energy”) are examples of such an “anti-gravity” force that can drive expansion (= inflation) of the universe.

- “Inflation Theory” = studies of what General Relativity predicts when “anti-gravity” or “inflation fields” are added to the equations.
What if an anti-gravity, inflation-producing inflation field with a chaotically varying intensity permeated the universe?
Eternal Inflation Multiverse

Inflation Theory

- In regions where the anti-gravity inflation field was intense, the fabric of space would be inflating at an enormous rate, producing enormous expanding voids of empty space.
- In regions where the anti-gravity inflation field was weak, the fabric of space would be inflating at a more leisurely, sedate rate – forming little bubble universes (perhaps like our own) amid the rapidly expanding voids.
There would also be fluctuations in the anti-gravity inflation field in the great expanding voids of space, forming weaker regions of inflation and the formation of more “bubble” universes. And so on for eternity.
Eternal Inflation Multiverse

Inflation Theory

Bubble universes amid rapidly expanding voids of space
The picture is that space at large is an eternally expanding void, within which chaotic inflation fields continually spawns new universes like a child blowing bubbles (= the Eternal or Chaotic Inflation Multiverse)

Bubble universes amid rapidly expanding voids of space
In 2003 Arvind Borde, Alexander Vilenkin, and Alan H. Guth proved a theorem (BVG Theorem) that any universe (or multiverse) that has an average expansion greater than zero must have had a beginning (a past space-time boundary) – regardless of the physics of that universe.

- The Eternal or Chaotic Inflation Multiverse must have had a beginning (= cannot be eternal in the past, that is, “past-eternal”)
“It is said that an argument is what convinces reasonable men and a proof is what it takes to convince even an unreasonable man. With the proof now in place, cosmologists can no longer hide behind the possibility of a past-eternal universe …”

- Alexander Vilenkin
The String / M-Theory Landscape Multiverse
The String / M-Theory Landscape Multiverse is an *elaboration* on the Eternal or Chaotic Inflation Multiverse.

- It allows the bubble universes of the Eternal Inflation Multiverse to look very different from one another, with different types of matter and forces (= different local law of physics).
- The full set of allowed local laws is known as “The Landscape.”
The Landscape Multiverse

The Great Problem in Physics

- What is *String Theory / M-Theory* that is the basis of this elaboration on the *Eternal or Chaotic Inflation Multiverse*?
- The two greatest achievements of 20th century physics were:
  - Quantum Theory – explaining the fundamental forces of electromagnetism, the weak force, and the strong force (the later two forces acting primarily at the subatomic realm of reality)
- *The Great Problem in Physics*: the above two theories are incompatible and hence flawed / incomplete.
  - In situations – like the early universe immediately after the Big Bang – when *both* gravity and quantum effects are important, we have *no reliable theory* to understand what is going on.
Einstein spent the last 4 decades of his life working on a theory to unite the forces of gravity and electromagnetism, and failed.

The current leading candidate to unite gravity and quantum theory is “M-Theory” (the successor to String Theory).

- **String Theory**: the attempt to describe all the particles and forces of nature as differing vibrations on tiny subatomic 2-dimensional “strings.”
- **M-Theory**: the attempt to describe all the particles and forces of nature as differing vibrations on tiny subatomic 3-dimensional (or higher n-dimensional) “membranes” or “branes”. (M=membrane).
Despite decades of work, there is still no successful M-Theory uniting gravity and quantum theory.

Theoreticians have determined that a successful theory will have to involve:

- 10 space dimensions
- 1 time dimension
The Landscape Multiverse
String Theory / M-Theory

We only see three space dimension (not 10!). In **String Theory / M-Theory**, the extra dimension are “curled” up and hidden in subatomic sized geometric forms called **Calabi-Yau manifolds** or shapes.

A Calabi-Yau manifold
The Landscape Multiverse

String Theory / M-Theory

- A Calabi-Yau shape is envisioned at every point in 3-dimensional space, “curling-up” or “compacting” and hiding the other 7 space dimensions.
In turns out that there are about $10^{500}$ different ways of compacting or curling up the extra dimension in various Calabi-Yau manifolds, and each potentially yields a different set of physical laws and describes a different universe.

Theoreticians haven’t figured out a way to pin point which of the $10^{500}$ possibilities describes our universe (if any of them do!), and they don’t have time to explore each one separately.
This state of affairs have caused some physicists to conclude there is something rotten in the state of physics, which continues to devote so much energy to a still unsuccessful theory with $10^{500}$ possibilities, a theory that has not yielded a single prediction that can be tested.
Unfazed, some cosmologists have conjectured that the $10^{500}$ possibilities in M-Theory describe a “landscape” of possible universes, and that when bubble universes are spawned during Eternal Inflation, they can take on any one of the $10^{500}$ possibilities of the landscape, leading to the Landscape Multiverse.
The Landscape Multiverse, as an elaboration on the Eternal Inflation Multiverse, is still subject to the **Borde-Vilenkin-Guth Theorem** – that any universe / multiverse with an average expansion greater than zero cannot be eternal in the past.

- The **Landscape Multiverse** cannot be eternal in the past; it must have had a *beginning*. 
Braneworld Cyclic Multiverse = Ekpyrotic Multiverse
String / M-Theory allows for the possibility of not just subatomic “branes” whose vibrations give rise to the particles and fields of the universe, but that the universe itself could be an enormous brane floating in a higher dimensional space with other branes (a “braneworld”)

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**Braneworld Cyclic Multiverse**

**The Braneworld**

- **String / M-Theory** allows for the possibility of not just subatomic “branes” whose vibrations give rise to the particles and fields of the universe, but that the universe itself could be an enormous brane floating in a higher dimensional space with other branes (a “braneworld”

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**Parallel branes**
If that is correct, then perhaps the "Big Bang" was a collision between two big branes.

A collision could be sufficiently energetic to produce conditions similar to the Big Bang, causing the two branes to rebound.

Mutual gravity (possible between branes in a braneworld) might then attract them to collide again (another Big Bang) – and we have a **Braneworld Cyclic Multiverse** (also known as the **Ekpyrotic Universe**, from the Greek *ekpyrosis*, meaning conflagration).
The Braneworld Cyclic Multiverse (Ekpyrotic Universe) would still have an average expansion of greater than zero, and thus, according to the Borde-Vilenkin-Guth Theorem, cannot be eternal in the past.

The Braneworld Cyclic Multiverse must have a beginning.
God and All the Multiverses

No Perpetual Motion Machines

- All the multiverses we have considered (the most commonly purported scenarios):
  - Level I Multiverse = “Quilted” Multiverse
  - Bouncing Multiverse
  - The Eternal or Chaotic Inflation Multiverse
  - The String / M-Theory Landscape Multiverse
  - Braneworld Cyclic Multiverse = Ekpyrotic Multiverse

- All these multiverses require a *beginning* because of considerations of thermodynamics (the buildup of entropy) and /or the **Borde-Vilenkin-Guth Theorem**.

- This “need for a beginning” can be thought of as confirming there is no such thing as a perpetual motion machine – and that includes the giant “machine” we label “universe” or “multiverse.”
If there is a beginning, then the “second way” argument for God by St. Thomas Aquinas, 1224-1274 has power:

1. Everything we see in this world is caused.
2. Nothing can be the cause of itself.
3. There cannot be an infinite regress of causes – because the multiverse has a beginning. Its past is finite.

Therefore:

4. There must exist an uncaused first cause not of this world (not of the multiverse)
5. The word God means “uncaused first cause not of this world (not of the multiverse)”.
6. Therefore, God exists.
There is currently no compelling scientific reason to accept the multiverse.

But might a believer in God have any reason to prefer a “multiverse” over a “universe?”

God is considered infinite and infinitely creative:

- Would it not make sense that creation would reflect these attributes?
- Would it thus not make sense that physical reality might be much larger than one universe?
God and All the Multiverses

God as Infinitely Creative

- A “universe generating mechanism” like the M-Theory Landscape Multiverse elaboration of the Eternal Inflation Multiverse might seem like an inefficient way for God to create a cosmos fruitful of life –

- But who says God must be like a great engineer trying to create a life-permitting cosmos with the least amount of material?
  - Perhaps God is more like a great artist expressing His/Her profligate and infinite creativity and ingenuity.
  - Perhaps God is an engineer with infinite power and materials available, and hence does not necessarily care much about efficiency.
God and All the Multiverses

God as Infinitely Creative

- In our time, C. S. Lewis in his fantasy series *Chronicles of Narnia*, imagines God to have created a large number of different realms of being.

- In the 16th century, the Dominican friar, philosopher, mathematician and astronomer Giordano Bruno (1548-1600) declared:
  - “Thus is the excellence of God magnified and the greatness of his kingdom made manifest; he is glorified not in one, but in countless suns; not in a single earth, but in a thousand, I say, in an infinity of worlds.”
Next Time:
A Universe Finely Tuned for Life