

## **Cosmology and Religion**

(Third in a series of four sermons on heeding the guidance of reason and the results of science)

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### **Readings**

1. The ambition to construct a scientific theory that could explain the world, as conceived from the seventeenth to the early twentieth centuries, shares a great deal with the search to know God. Both of them are a search for the absolute, for an understanding of the world that attributes its beauty and order to an eternal and transcendent reality “behind” the world. In diverse aspects of the production of European culture in these centuries – in the sciences, philosophy, theology, and art – one sees a striving to construct an absolute and objective view of the world that would ground the vicissitudes of our lives in an eternal and unchanging greater reality. Whether the talk is of God, or of an eternal and universal Law of Nature, the idea that dominates is that the rationality responsible for the coherence we see around us is not in the world, but behind it. – Lee Smolin, “The Life of the Cosmos”, Oxford, 1997
2. It’s only through the rational pursuit of theories, even those that whisk us into strange and unfamiliar domains, that we stand a chance of revealing the expanse of reality. – Brian Greene, “The Hidden Reality”, Knopf, 2011
3. Over the course of nearly five centuries, the Copernican progression has been a dominant theme. From the rising and setting of the sun to the motion of constellations across the night sky to the leading role we each play in our mind’s inner world, experience abounds with clues suggesting that we’re a central hub around which the cosmos revolves. But the objective methods of scientific discovery have steadily corrected this perspective. At nearly every turn, we’ve

found that were we not here, the cosmic order would hardly differ. We've had to give up our belief in earth's centrality among our cosmic neighbors, the sun's centrality in the galaxy, the Milky Way's centrality among the galaxies, and even the centrality of protons, neutrons, and electrons – the stuff of which we're made – in the cosmic recipe. There was a time when evidence contrary to long-held collective delusions of grandeur was viewed as a frontal assault on human worth. With practice, we've gotten better at valuing enlightenment. (TW add-on: Some of us, that is.) Op. cit.

### **Introduction**

What in the world does cosmology have to do with religion? Well, since cosmology is the study of the universe writ large (or universes, as we will shortly see) and religion for many is a very intimate, personal matter involving one's soul and its preservation for eternity, some would say nothing. What concern are distant galaxies to me, the less curious observer might ask? I'm interested in what brings me comfort and hope for the future, and that's here and now.

For others, however, cosmology represents the study of the entire physical realm of existence. For them, there is nothing beyond. Everything they can imagine, if it exists, must be somewhere in this physical realm, and so it is reasonable to look to cosmology to uncover the secrets as to where everything came from, what all is in the mix, and where will it all go. If there is a god or gods, cosmologists surely have the license to look for them, just like they look for dark matter and try to fathom the nature of dark energy. Cosmologists are the ones whose obligation it is to see how far science can take them in explaining how everything came to be, and thus whether a supernatural entity has to be invoked at the boundary of their knowledge. With reference to my previous talk where I introduced Religion Part A (the supernatural dimension) and Religion Part B (the moral dimension),

cosmology probes the last defense Religion Part A has against the inexorable march of science, namely that there has to be a supernatural being that got everything started and enabled it to work. The Deists of old extended their doubts about the supernatural this far, but then gave in. They couldn't fathom a universe just springing into being on its own and working as magnificently as it does. A supernatural power had to at least get it all started. But cosmologists can fathom this, as posited, for example, in one theory of universes popping into and out of existence, with some, such as ours, having especially propitious parameters, lasting longer than most. Today, I want to share with you some of the latest theories about the cosmologists' realm of all existence so you can appreciate how far they have pushed forward with no capitulation to the supernatural. Much of what follows comes from the excellent book Julie quoted from at the beginning, "The Life of the Cosmos" by Lee Smolin (1997), and from Brian Greene's book that I just quoted from.

There are two yes/no questions that take us to the heart of religion and cosmology. The historical view of the universe from Aristotle through Newton and on to Einstein was that it was possible to view it in its entirety from the outside, and this is indeed what a god or the gods did. The concept of a detached, non-interacting observer was paramount. Springing from quantum mechanics in the 1920's, however, as embodied in Heisenberg's Uncertainty Principle, the act of observing something means interacting with it, and thus being in the same universe as it is. Cosmologists no longer accept the concept of an external observer. As Lee Smolin puts it, "...is it possible to imagine a science that aspired to a complete and objective description of the universe while, at the same time, denying the possibility that that description could be read as the view of a being outside of the universe? The answer to this question is yes."

The second question relates to the uniqueness of our universe, threatening to move us to yet another phase of the Copernican progression. Was the Big Bang that spawned our

universe a unique event or is it something that may have happened before and could happen again? If it's the latter, think about how still more insignificant humans suddenly become! And just think also about how there's nary a mention of any of this in the words from the prophets of old. Now why would that be???

### **The Very Large and the Very Small**

Cosmologists, looking at the birth and fate of our universe, study phenomena that occur on the largest scale imaginable. Our universe is 13.7 billion years old, so photons of light traveling in opposite directions for that long are at least 27.4 billion light years apart, actually even further when cosmic expansion is taken into account. (A light year is about 6 trillion miles.) In fact, the most distant visible objects are now about 42 billion light years away, meaning the diameter of our visible universe is twice that, or 84 billion light years. The volume of this expanse –  $\frac{4}{3} \pi (42 \times 10^9)^3$  cubic light years – is called the Hubble volume. We're talking about a BIG playpen here! Cosmologists and astronomers routinely talk not only of stars in galaxies (100 billion stars in a galaxy) but galaxies in clusters (dozens to thousands of galaxies per cluster) and patterns of clusters, perhaps one of the most famous being the "Great Wall", a sheet of clusters of galaxies about 30 million light years away.

At the same time, however, these investigators, with the help of their particle physics friends, must also comprehend phenomena at the very smallest of scales, the so-called Planck scale, around  $10^{-35}$  meter, where space itself may be quantized. This is where the latest theories on the essence of matter focus, the most promising such theory being string theory, which holds that the most elementary objects in existence are not point particles like electrons and quarks that we're accustomed to thinking of. Rather, these objects are seen to be one-dimensional strings that can vibrate in many different modes, with each mode manifesting itself as a different particle. It is string theory in the main that physicists hope

will ultimately lead to their holy grail, a so-called “Theory of Everything”, which will finally unify Einstein’s general relativity with the quantum mechanics of Schrodinger and Heisenberg, or, said another way, harmonize the gravitational force with the other three fundamental forces of nature, the most well-known one being the electromagnetic force. Two of the important reasons cosmologists are keenly interested in string theory are, first, to understand the Big Bang, where the first phenomena occurred at these sub-sub-microscopic scales, and, secondly, to understand the nature of dark matter and dark energy that are now known to pervade our universe.

Combining their knowledge of the very large and the very small, cosmologists have come to a much more promising position in their quest to fully understand the universe, in particular coming up with view that does not require or even permit an outside observer, does not look for a fundamental principle that leads precisely to laws of nature as we divine them, and explains how it is that our particular universe exhibits the finely tuned laws and parameters that enable us to exist. The path, then, from here to the end of my talk this morning picks up with the anthropic principle as a starting point, then takes a major step forward with a brief elucidation of the near inevitability of parallel universes, with the help of Brian Greene, and finally brings us to an intriguing hypothesis advanced by Lee Smolin that posits that our extant universe sprang from a process of self-organization not unlike that customarily associated with biological systems.

### **The Anthropic Principle**

The anthropic principle is the launch pad that cosmologists are attempting to spring free from and thus leave behind. It comes in two forms, a strong form and a weak form. Whether we know it or not, we are intimately familiar with the strong form, which simply posits that a supernatural power, usually god, created the universe precisely as it is so it would be hospitable to life, especially human life, with the result that humans would come

to know, love, and worship him or her. As scientific understanding progressed, however, this formulation became too far-fetched for many to accept, but there was still no plausible hypothesis for how all 20 or so of the fundamental constants of nature – mainly the strengths of the four fundamental forces, their ranges of influence, and the masses of the stable elementary particles – acquired exactly the values required for our universe to be stable and hospitable to long-lived stars necessary to forge the stable elements from which we are all made. Smolin estimates that the probability of these constants simultaneously exhibiting their known values strictly by chance is one in  $10^{229}$ ! So the weak form of the anthropic principle came to the fore, offering a way to explain our existence without putting it squarely at the feet of a supreme being. This form begins with the postulate that there is a large number of universes, or regions of the universe, of which ours is only one and adds the postulate that the laws of physics, or at least their parameters, are different in these different universes. The deduction, then, is that we humans could only find ourselves in one of a community of universes that are hospitable to our existence and that at least one such universe has indeed arisen, no matter how improbable, to our benefit. So here we are! The anthropic principle does not reflect good science, however, because it does not offer one or more predictions that can be falsified. It does draw attention to parallel or multiple universes, though, and I'd like to touch on this subject briefly before moving to the end.

### **Parallel Universes**

The basic idea of parallel universes is that our universe and how it came to be are not unique -- that we live in one universe of many, the whole collection being referred to as the multiverse. The difficulty here, of course, is that there is no way for us to observe any of these other universes, else they would be part of ours! So in seeking at least some experimental basis for their existence, we have to proceed indirectly, looking at our newest

theories of matter and gravitation, such as string theory noted above, to see if they can be supported experimentally and then, in turn, if they point to a multiverse. Brian Greene's book, *The Hidden Reality*, which I quoted at the beginning, takes the reader down precisely this path, looking at nine different ways current theories lead in this direction. I don't have time to describe each theory this morning, but I can offer a few highlights on both the experimental and theoretical sides.

Perhaps the simplest path to multiple universes is the one based on the assumption that our universe is infinite, really infinite! This assumption has not been proven, but an assay of the amount of ordinary and dark matter in the universe comes very close to the critical density of the equivalent of about six hydrogen atoms per cubic meter needed for the universe to have neither positive nor negative curvature, but to have instead a flat geometry. And a flat geometry is one that can have an infinite extent. Moreover, a curved geometry leading to a finite universe might result in multiple images of the star field resulting from light circling the universe and coming around again. Such images have never been observed. If the universe is indeed infinite, because there is a finite number of ways all the matter in our Hubble volume can be configured, this pattern must necessarily repeat. That is, because the universe is assumed to be infinite, if you could go far enough – on the order of  $10$  raised to the  $10$  to the  $122^{\text{nd}}$  power in meters – you would encounter another patch just like ours with a person identical to you doing exactly what you are doing now – perhaps yawning and wondering if this talk will ever end! And there would be a patch configured the way ours was the moment you were born, meaning you were being born all over again and thus, in a sense, enjoying everlasting life! And without professing any particular religious belief! Amazing! If you find this terribly far-fetched, as I tend to do, at a minimum it should give you a better sense of what infinite really means! For the record, this concept of parallel universes is often termed the “Quilted Multiverse”.

I know time is running short, but I must take the time to acquaint you with one more concept of parallel universes, because it too has strong, though not absolute, experimental support. In the early 1960's, theorists at Princeton studying the Big Bang postulated that there must be some radiation permeating the universe left over from this event, and indeed two researchers at Bell Labs thirty miles distant stumbled upon it while testing a radio communications antenna. It is known as the cosmic microwave background radiation, and its long wavelength equates to a temperature throughout the universe of about 2.725 degrees Kelvin, very close to absolute zero, which is zero Kelvin or  $-273$  degrees Celsius. By carefully analyzing this radiation in more recent years, physicists have documented its surprising uniformity on the one hand – constant to within about one part in a thousand – and a fine structure exhibiting a repeatable pattern of tiny differences as a function of the angular separation between any two points in the sky. From this they have deduced the theory of Cosmological Inflation, which posits that in its earliest instants, our universe went through an extremely short, intense burst of expansion, faster than the speed of light, that enabled it to come to thermal equilibrium and then have its photons burst forth to produce their observed positions in the sky. The punch line of all this, however, is that cosmological inflation could be a recurring phenomenon, occurring repeatedly in such a way as to spawn a multiverse of bubble universes! Think of a scuba diver exhaling as he or she swims among the coral leaving a multitude of universes in his or her wake!

Before wrapping up, let me note in passing that string theory also leads to multiple universes. For those of you who might know a little about string theory – raise your hands if you do – you are probably aware that it introduces the concept of extra dimensions besides time, height, width, and depth we are familiar with. Its parallel universes arise through the multitudinous ways these extra dimensions can be realized. Be aware, however, that string theory still awaits some form of experimental support. The Large Hadron Collider at CERN on the French/Swiss border (which Jack and Sue Majors have

visited, by the way) may find some evidence of these extra dimensions or one or more of the particles predicted by string theory's corollary principle known as supersymmetry.

The bottom line, in any case, is that it is far more likely there are additional universes besides our own rather than ours being the only one. To wrap up today's talk, then, let me outline one mechanism, as postulated by Lee Smolin, for how our particular universe came to have the very precise characteristics it has, necessary for us to exist. Call it the "theory of the evolutionary multiverse". It starts with two postulates: (1) Quantum effects prevent the formation of singularities, such as inside black holes, at which time starts or stops; instead, there is an explosion, or "bounce" in a black hole, when matter is squeezed to an enormous density, about  $10^{79}$  times denser than an atomic nucleus. Time branches like a tree, so that each black hole is a bud that leads to a new universe of moments. (2) During a bounce, the basic laws of physics don't change, but the parameters of the standard model do change during the bounce in small and random ways. For most values of the parameters, stars cannot exist and black holes cannot form. For a small range of values, however, a universe will produce many more black holes than for other values. Assuming universes spring from black holes, and ours is a typical universe, then our universe will have those values of the parameters that favor the production of black holes. In other words, *the parameters of the standard model of elementary particle physics have the values we find because these make the production of black holes much more likely than most other choices*. The analogy with Darwin's theory of evolution is apparent: The species of flora and fauna we see are those that are favored with attributes that enhance their reproduction over other possibilities. So it may be with universes, according to Smolin's hypothesis. We still have to explain, however, how the first universe came about, just like we're not quite sure just how the first reproducing life form on earth arose. According to Richard Dawkins in *The Blind Watchmaker*, "The theory of evolution by cumulative natural selection is the only theory we know of that is, in principle, capable of

explaining the existence of organized complexity.” Dawkins was referring to life on earth, but Smolin says he could just as well have been referring to the origin of our universe!

So what does all this say about Religion Part A? In a nutshell, the Copernican progression continues, mankind on earth becomes ever more insignificant, and the need to invoke a god to understand our existence grows steadily weaker. Is there an endpoint when all is understood? Probably there is, but we won't be reading about it in the New York Science Times anytime soon!

Thank you!