

THE BIG BANG, STEPHEN HAWKING AND GOD*

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This is one of many lectures in a series and some of this can be found, at least in an early stage, in my book *Science and Christianity: Conflict or Coherence?*

Now I'd like to begin with a short description of the place we work. The computational chemistry building of the University of Georgia is the first building in the world constructed exclusively for research in computational chemistry. Computational chemistry is the fastest growing part of chemistry.

It's also important that I relate my own research to the work I'm going to talk about this morning. So this is the beginning of our research in astrophysics – a paper published in *Nature* thirty-two years ago, related to the synthesis and detection of molecules in interstellar space. The essence of our work is that we were able to identify a number of molecules in interstellar space that had been mysterious before. We have been continuing this research for more than thirty years; several other papers were published in *Nature*, more in the astrophysical journals. This is a topic I'll be speaking on at a large meeting in Honolulu in December.

Our subject this morning is *cosmology*. Cosmology is the study of the Universe as a whole, its structure, origin and development. Questions cosmology addresses are profound, both scientifically and theologically. Let me begin with a few of the questions, without promising to answer them all.

1. Is the Universe finite or infinite in content and extent?
2. Is the Universe eternal or did it have a beginning?
3. How old is the Universe?
4. Was the Universe created? If not, how did the Universe get here?

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5. If the Universe was created, then how was this creation accomplished and what can we learn about the evidence and agent of creation.
6. Who or what governs the laws and constants of physics?
7. Are these laws of physics a result of chance or have they been designed?
8. How do these laws relate to the support and development of life?
9. Is there any existence, noble existence beyond the known dimensions of the Universe?
10. Is the Universe running down irreversibly, or will it bounce back?

So I think these questions define the field of cosmology better than any standard definition. The most controversial of all those questions is the age of the Universe. Many great scientists have dreamed of a Universe that was infinitely old. The idea that the Universe had a particular time of origin has been philosophically resisted by some very distinguished scientists. Arthur Eddington, who observationally confirmed Einstein's general theory of relativity, twelve years later made this statement: "Philosophically, the notion of a beginning to the present order (of nature) is repugnant to me. I should like to find a genuine loophole." So Eddington dreamed of the Universe that was infinitely old and Einstein dreamed of the Universe that was infinitely old. And closer to Poland Walter Ernst dreamed of the Universe that was infinitely old.

Let me say a little bit about Einstein's objections to the idea of the beginning for the Universe. Einstein's reaction to the consequences of his own General Theory of Relativity appears to acknowledge the threat of encounter with God. Through the equations of general relativity we can trace the development of the Universe backward to its origin. Einstein did not like the idea of an origin. However before publishing his *cosmological inferences*, Einstein introduced a *cosmological constant* to force the Universe to be infinitely old. Einstein desperately wanted the Universe to be infinitely old. He later considered this to be the greatest mistake of his scientific career, and later gave ultimate acceptance to what he called "the necessity for a beginning"; eventually to what he called "the presence of a superior reasoning power". But Einstein never did embrace the concept of a personal creator, a compassionate God who cares about women and men, girls and boys.

Why such a tremendous resistance to the notion of the beginning of the Universe? Many of you will be familiar with the five ancient arguments for the existence of God. Thomas Aquinas wrote on these arguments in tremendous detail, but they can all be found seven hundred years earlier in the writings of Augustine, although without such a lengthy discussion. The first argument is *the cosmological argument* – the effect of the Universe existence must have a suitable cause. This is a problem for Einstein, for Eddington, for Walter Ernst and for others. We don't have time to mention the other four arguments.

So, what is the problem, why such a resistance to a definite beginning for the Universe? I think we can break the cosmological argument into three parts. First: everything that begins to exist must have a cause – cause and effect. There are very

few scientists who would disagree with cause and effect. If this overhead projector were to blow up, in a few minutes (and I've seen overhead projectors blow up) everyone here would think there was a cause. So cause and effect is perhaps the most important ingredient in science. And scientists would be very hesitant to ignore it. Everyone believes in cause and effect.

Now suppose the Universe begins to exist – then the Universe must have a cause. And I think you can see that this direction, this logic is leading where many people would be uncomfortable. So the cosmological argument is a powerful argument against those who deny the existence of God. If the Universe was infinitely old, then the cosmological argument is irrelevant. If the Universe has a beginning, then God exist.

In 1946 George Gamov, the Russian-born American physicist, proposed that the primeval fireball or Big Bang was an intense concentration of *pure energy*. The Big Bang was the source of all the energy that now exists. The Big Bang theory predicts that all the galaxies in the Universe should be rushing away from each other at high speed. Twenty years later the observation of microwave background radiation, by Arno Penzias and Robert Wilson, convinced most scientists of the validity of the Big Bang theory of the origin of the Universe.

Further observations in 1992 have moved the Big Bang theory from a priority view to one that is almost unanimous among cosmologists. There was the beginning to the Universe, perhaps fourteen billion years ago. Let me offer a future dictionary definition of the Big Bang theory. The Hot Big Bang Theory states that the entire physical Universe – all the matter and energy and even the four dimensions of space and time, burst forth from the state of infinite or near infinite density, temperature and pressure - most unusual set of circumstances.

Perhaps just a little bit of summary of the evidence for the Big Bang theory. This is from my Berkeley colleague Joseph Silk. Silk and I joined the Berkeley faculty in 1969, and we both left in 1987. So these are Joseph Silk's words: "The Hot Big Bang model is enormously successful. It provides the framework for understanding the expansion of the Universe, the cosmic background radiation and the primeval abundance of light elements, as well as a general picture of how the structure seen in the Universe today was formed."

Arno Penzias, one of the two discoverers of the microwave background radiation, made this statement six months before it was announced that he was to receive a Nobel Prize in physics. This is what he said: "The best data we have (concerning the Big Bang) are exactly what I would have predicted, had I nothing to go on but the five books of Moses, the Psalms, the Bible as a whole." So you can see that the borderline between science and religion is very porous.

More recently Arno Penzias was asked: "Why was it that so many cosmologists were so affectionate in their embrace of the steady state theory? Why did Einstein, Eddington and many others dream of the Universe that was infinitely old?" I think Penzias does a good job of answering this question. He said, "Well, some people are uncomfortable with the purposefully created world. To come up

with things that contradict purpose, they tend to speculate about things they haven't seen."

I've given this lecture in many parts of the world, never before in Poland. I made seven trips to India and seven to China. Two years ago I was able to give this lecture with the slightly different title in Chengdu, the capital of the Sechuan Province. City of ten million people, and amazingly we were able to ask all the students for comments on the lecture. This is a very new thing in China to ask students questions about religion. About fifty of the students said the same thing – they said: "This lecture needs more pictures."

So I've introduced some pictures into the lecture. One of them is the photograph of Arno Penzias, the man who said that the Big Bang is completely consistent with the Bible. Another one is of Wilson, and the apparatus they used in 1965 for their experiment. But this picture is only five years old. So the great discovery of Penzias and Wilson took place 30 years earlier.

Denis Sciama is a person I want to introduce now; he is important for two reasons, first he was the thesis advisor of Steven Hawking, and secondly he was the most brilliant advocate of the steady state hypotheses. He was the best of those who believed the Universe to be infinitely old. He abandoned this belief about ten years ago, but he did so in a remarkable manner. Here is his statement, shortly after he gave up on the steady state hypotheses. He agreed that there was an origin to the Universe, but he said this with a good sense of humor. He said: "The Steady State Theory" – the idea that the Universe is infinitely old – "has a sweep and beauty that for some unaccountable reason the architect of the Universe appears to have overlooked." This is a wonderful explanation of every failure in science – I cannot understand why God didn't use my idea. That's a very good sense of humor.

The real death of the Steady State hypothesis was concluded in 1992, thirteen years ago, due to the so-called Big Bang ripples experiment observed by the COBE satellite. COBE (Cosmic Background Explorer) was a satellite experiment. It's unusual when the front pages of major newspapers all around the world have as the first story, a story about science. But that happened on April 24 in 1992. Many headlines said that "It's like looking at God". This was the statement by George Smoot, the scientific team leader. George Smoot and I were classmates at MIT. We both arrived in September of 1962, and we both graduated in May of 1966. Nevertheless it was an extreme shock to me to discover that George Smoot was the famous scientist. His name, the name Smoot was associated with rather different source of activities at MIT. And those who have visited the MIT campus would know what I mean. One week after George Smoot announcement of the Big Bang ripples experiment, Frederick Burnham, well known science writer in the Los Angeles Times, made this statement: "These findings, now available, make the idea that God created the Universe a more expectable hypothesis today than at any time in the last 100 years."

Now that does not mean that everyone agreed. Geoffrey Burbidge, a British astrophysicist living in San Diego, California, for a long time, still rejects the COBE conclusions. Burbidge still believes that the Universe is infinitely old, even though this means he disagrees with all cosmologists. What is perhaps the most remarkable is the manner in which Burbidge rejects the Big Bang theory. He claimed that the Big Bang experiments, the Big Bang ripples experiments are coming from what he describes as the First Church of Christ of The Big Bang. George Smoot's first response to this cannot be repeated in polite company. But when he recovered sufficiently, George said, "Not one member of my team, none of my seventeen team members is a member of the First Church of Christ of the Big Bang". Burbidge continues to favor the Steady State hypothesis. A view that – he says – supports Hinduism not Christianity. And it is certainly true that if the Universe were infinitely old, this would be support for Hinduism. Unfortunately for Hinduism the Universe is not infinitely old.

Let me show you another picture. The Big Bang took place a long time ago; none of our ancestors were there. So this is an artist's representation of the Big Bang. Here we have a small speck down at the bottom. The dot in this picture is way too big. The size of the original singularity is perhaps twenty orders of magnitudes smaller than that, a billion, billion, billion times smaller than that, very small. In a short period of time after the big bang (10^{-35} s) inflation begins; in one second atomic nuclei were formed; after half a million years the Universe cooled down. Here we are, fourteen billion years later, and the Universe continues to expand. At this point we are beginning to realize that bigger issues are involved than simple scientific observations.

So let me say a little bit about that. Hugh Ross in his book *The Creator and the Cosmos* writes, "By definition, time is that dimension in which cause and effect phenomena take place. If time's beginning is concurrent with the beginning of the Universe, as the space-time theorem says, then the cause of the Universe must be some entity operating in a time dimension completely independent of and pre-existent to the time dimension of the Cosmos." That is to say, God is of higher dimensionality than we are. Human beings experience four dimensions: three directions and time. God is extra dimensional. Ross continues, "This conclusion is powerfully important to our understanding of who God is and who or what God is not. It (the Big Bang theory) tells us that the Creator is transcendent, operating beyond the dimensional limits of the Universe. It tells us that God is not the Universe itself, nor is God contained within the Universe."

When I gave this lecture somewhere in the middle of the United States, sometimes students objected to this. They say that they have never known anyone who believed that God is Universe or who believed that God is contained within the Universe. So I have to share with them from many trips to China and India that more than two billion people living on this planet believe either that God is the Universe, or that God is contained within the Universe. If the Big Bang theory is true, both of these conclusions are wrong.

Many have spoken on this topic and one of the best books, I think, is called *The Dancing Universe*, by a university physics professor Marcello Gleiser. He talks about the classification of cosmological models. He says that there is one big question: “Is there a beginning?” If there was no beginning, if the Universe is infinite, there are number of possibilities consistent with Hinduism and other eastern believes. Now if there is a beginning, creation from something, namely from God, then Genesis, the Big Bang theory and certain kinds of philosophical Hinduism might come over here. But there is a choice: there was a beginning or there was not a beginning. If there was a beginning, these are possible understandings of the world or these are not possible understandings of the world.

I want to summarize what I’ve said thus far with a statement by Leon Lederman, a Nobel Prize winner in physics and author of an interesting book called *The God Particle*. This is just an introduction to the book but it’s the best part: “In a very beginning, there was a void – a curious form of vacuum – nothingness containing no space, no time, no matter, no light, no sound. Yet the laws of nature were in place and this curious vacuum held potential. A story logically begins at the beginning. But this story is about the Universe and unfortunately there are no data for the very beginning. No human observers, none, zero. We don’t know anything about the Universe until it reaches the mature age of a billionth of a trillionth of a second – that is, some very short time after creation in the Big Bang. When you read or hear anything about the birth of the Universe, someone is making it up. Only God knows what happened at the very beginning.”

Good statement. And others have said much the same. In his book *A Brief History of Time* Stephen Hawking says: “The actual point of creation lies outside the scope of the presently known laws of physics.” And Alan Guth, his Northern American counterpart has stated: “The instant of creation remains unexplained.”

Alan Guth is the most outstanding cosmologist in North America. I am sure many of you think that scientists are very orderly in their work. But Alan Guth’s office is not very orderly. It does serve the purpose though. Alan Guth is a very busy man, so there are no seats in his office except his own. So anyone who comes to visit him must stand up the whole time. So they don’t stay very long.

We want to say something about Stephen Hawking’s scientific research, of course. Hawking has made his reputation by investigating in great detail one particular set of problems: the singularities and horizons around black holes and at the beginning of time. Here is “future” dictionary definition of a black hole: a massive system so centrally condensed that the force of gravity prevents everything within it, including light, from escaping. A black hole had never been observed directly. Black holes are observed because of their influence on other heavenly bodies.

Stephen Hawking’s most famous research was carried out when he was a Ph.D. student at Cambridge University. It was carried out with two other students: Roger Penrose and George Ellis. All three are very famous now. Roger

Penrose is a theist of some unspecified sort. Stephen Hawking is probably agnostic. George Ellis is definitely a Christian. In the earliest work of all three, they demonstrated that every solution to the equations of General Relativity Theory guarantees the existence of singular boundary for space and time in past. This result is now known as the Singularity Theorem, and is as close as we can get to a mathematical rationalization for the Big Bang Theory. Obviously Hawking went on from this to do research by himself and with his own students. In 1973 he began to formulate ideas about the *quantum evaporation of black holes, exploding black holes, Hawking radiation*, etc.

Steven Hawking is certainly the most famous physicist in history, who has not received the Nobel Prize. Of course, this isn't too bad. There are four million other scientists who have not received the Nobel Prize. So he joined the large group, but he is the most famous scientist in the world. Two years ago the Swedish Royal Academy felt obligated to explain why he did not get the Nobel Prize. And they've said this: "A Nobel Prize must be supported by verifiable experimental or observational evidence". And Hawking's works remain unproven. Although the mathematics of his theory is considered beautiful and elegant, science waited until 1994 for rock solid evidence for even the existence of the first black hole. The verification of Hawking's radiation or his more radical proposals seems very far off. Even if some aspects of Hawking's work eventually turned out to be wrong, he have had the most profound impact on history of scientific thought. He is a great scientist.

In the book *A Brief History of Time* (20 millions copies of this book have already been sold) there is a main character. If you haven't read the book, that will surprise you. If you have read the book you will know that the main character of the book is God. So what shall we say about Hawking's ideas about God? May I also say that his ideas about God may be changing now, because he goes to church once or twice a month in Cambridge. So things may be changing. But the principle influence in Hawking's earlier life was his mother Isabel. Isabel Hawking was a member of the British Communist Party in the 1930's. She was a strong atheist and Stephen Hawking at least until recently has carried quite a bit of that tradition with him. In the year 1955 two of Stephen Hawking's closest friends became Christians as a result of the 1955 London Billy Graham's campaign. But Hawking seemed not to be effected.

On December 31st 1962 Stephen Hawking met a woman named Jane Wilde at the Christmas New Year Eve party. One month later he was diagnosed with a terrible disease – ALS. He was given two years to live. This is not unreasonably because I've had three friends who died of this disease. One survived two years after the diagnosis, one three years and one five years. Stephen Hawking has survived this disease for forty-three years. There is no precedence for surviving ALS this long. At the time of this diagnosis he was rather average performing graduate student at Cambridge University. Let me quote his biographers at this point. His biographers Michael White and John Gribbin say this: "(...) there is little doubt that Jane Wilde's appearance on the scene was a major turning point in

Stephen Hawking's life. The two of them began to see a lot more of one another and a strong relationship developed. It was finding Jane Wilde that enabled him to break out of his depression and regenerate some belief in his life and work. For Hawking, his engagement to Jane was probably the most important thing that has ever happened to him. It changed his life, gave him something to live for and made him determined to live. Without the help that Jane gave him, he would almost certainly not have been able to carry on nor had the will to do so."

He and Jane Wilde had three children together. Hawking has many times said that "what really made a difference" in his life "was that I got engaged to a woman named Jane Wilde. That gave me something to live for." There is a wonderful personal side to this story. Jane Hawking is a very interesting person in her own right. She has a Ph.D. in a medieval lyric poetry of the Iberian Peninsula. And I've now exhausted my knowledge of that topic. If there are some of you that know something about the medieval lyric poetry of the Iberian Peninsula I hope you'll be able to share it with us this evening. Jane Wilde is a Christian and made this statement: "Without my faith in God, I wouldn't have been able to live in this situation. I wouldn't have been able to marry Stephen in the first place because I wouldn't have had the optimism to carry me through and I wouldn't have been able to carry on with it."

The reason for Stephen Hawking remarkable success as a popular writer, not just as an author of articles in the physical review letters, but as an author writing about science to the general public, the secret is that he addresses these problems of meaning and purpose that concern all thinking people. The book overlaps with Christian believe and it does so deliberately, but graciously and without rancor. It is an important book that needs to be treated with respect and attention. Let me share with you where he introduces the main character in *The Brief History of Time*. The main character of course is God. This is on page about thirty of the book. Hawking says "It is difficult to discuss the beginning of the Universe without mentioning the concept of God. My work on the origin of the Universe is on the borderline between science and religion, but I try to stay on the scientific side of the border. It is quite possible that God acts in ways that cannot be described by scientific laws." Further clarification from Hawking: "I thought I had left the question of the existence of a Supreme Being completely opened (...) It would be perfectly consistent with all we know to say that there was a Being who was responsible for all the laws of physics."

Occasionally Stephen Hawking is accused of being an atheist. He always response very negatively and says, "I'm not an atheist". He was once asked if science and Christianity were competing worldviews. He replied: "Of course not. If that was true then Newton would not have discovered the law of gravity".

There are many wonderful things in the book *A Brief History of Time*. I only have time to share two. Here is the first one. Before reading this let me say that the great goal of Stephen Hawking and other quantum gravity theorists is what they call a Unified Theory or Grand Unification. This is the single theory that will unite

our understanding of gravity and quantum mechanic; gravity dealing with the largest bodies in our Universe and quantum mechanic dealing with the smallest ones. Grand Unification does not yet exist, but it is a goal. Hawking says this: “Even if there is only one possible unified theory” - let me emphasize that this hasn’t been proved yet - “it is just a set of rules and equations. What is it that breaths fire into the equations and makes a Universe for them to describe?” I think if you can answer that question you’re doing well.

My favorite quotation of all of Hawking is this one. You may be surprised to know that Stephen Hawking is a great admirer of St. Augustine. We’ll see this in this statement he made in *A Brief History of Time*. He addresses the idea that God might want to change his mind, and Hawking says “no” and he quotes Augustine. He says that Augustine has already solved this problem fifteen or sixteen hundreds years ago. “The idea that God might want to change His mind is” – according to Hawking – “an example of the fallacy, pointed out by St. Augustine, of imagining God as a being existing in time.” Hawking continues: “Time is a property only of the Universe that God created.” And now he shows us his excellent sense of humor – Hawking’s words: “Presumably, God knew what He intended when He set it up.” So we can see a remarkable interest in God expressed by Stephen Hawking.

Many things need to be said. We may run out of time before, but I do want to say something about the *fine-tuning* of the Universe. Most of scientific hypothesis can be traced back to something earlier, which can be traced back to something even earlier. Now I want to tell you about a recent discovery, fifty years ago. This idea doesn’t seem to be traced back. Certainly in the 1950’s something called the *Copernican Principle* was widely accepted. Copernicus was born around here. The Copernican Principle is not from Copernicus. It was just named after him. The idea of the Copernican Principle is that there is nothing unusual about our planet, there is nothing unusual about our Sun and there is nothing unusual about our Galaxy. The idea is that there are billions and billions and billions of planets just like ours; billions and billions and billions of suns just like ours. But this turned out to be not true.

Beginning of this revolution in science is dated to a person named Whithrow, fifty years ago. And this was a real revolution. In his first paper Whithrow said that a “variety of astronomical conditions must be met if a Universe is to be habitable”. Once this idea got out into the open, huge amount of data was found to support it. In 1986 British astronomer John Barrow was able to publish a book of seven hundred pages, titled *The Anthropic Cosmological Principle*. In this book Barrow notes that there are a surprising number of physical futures of the Universe that conspire to make life possible. Let me attempt to summarize this material very briefly. If we take any one of the fundamental constants of nature: speed of light, mass of the electron, mass of the proton and neutron, fine structure constant and so on – if we make any one of these constants one percent bigger or one percent smaller, there’s no life on this planet; life is gone. Life is remarkably fine-tuned to the planet Earth.

A number of influential books on this subject have been published in the last

five years. Two professors at the University of Washington have published a book entitled *Rare Earth*. More recently a professor of Iowa State University has published a book called *The Privileged Planet*. The conclusion of all these studies is that the planet Earth is very, very peculiar.

I'm just giving you "the tip of the iceberg". As far as the anthropic constraints circumstance, we could go on to talk about derived quantities in chemistry and physics. For example: the dipole moment of the water molecule. I think most of you know that our bodies are made of about seventy five percent water. Dipole moment of the water molecule is the fundamental measure of the polarity of that molecule. Every good physical chemist knows that it is one point eight four seven five debit units. If you make it one percent bigger or one percent smaller, none of us were here and this building was never constructed. And what's worse than that, even amebas don't exist. In the past years, fifty years, many great people have been bothered by these anthropic constraints. Not just Christians. George Greenstein is a professor of physics in Amherst College and he is something like a pantheist, but here is his statement: "As we survey all the evidence, the thought insistently arises that some supernatural agency or rather Agency – with a capital 'A' – must be involved." Then he asks two questions. "Is it possible that suddenly, without intending to, we have stumbled upon scientific proof of the existence of a Supreme Being? Was it God who step in and so providentially created the Cosmos for our benefit?"

Let me conclude our time together by trying to answer these questions. Do the anthropic constraints provide scientific clue for God? I don't think so. I'm not a Thomist. I have many friends who are Thomists, great admirers of Thomas Aquinas. I'm an admirer of him, but I'm not a Thomist and I don't think we can prove the existence of God. On the other hand, I think the evidence for the existence of God is strong. Was it God who step in and providentially, so providentially, created the Cosmos for our benefit? Yes.