Hermann Lecture Series 2022: Perry Phillips, Big Bang: The Beginning of the Universe (Part 1): The Expanding Universe/Red Shift

Biblicalelearning.org by Ted Hildebrandt

Thank you very much, Dr. Brink. Thank you for coming. Thank you to Gordon College for the opportunity to speak here.

And thank you very much to the Herman family and to Templeton for being able to arrange these particular lectures. And I also, you mentioned, what is a quality assurance engineer? I made sure things worked. That developer's dead.

In fact, if any of you have Verizon voicemail, any of you have Verizon voicemail? I don't blame you for not having it. No, actually, I did some of the testing of the voicemail back when they were trying to get voicemail and SMS messages working with Verizon. So that is quality assurance is making sure things work.

I'm very happy today, however, to not speak about quality assurance, but to speak about something that I've enjoyed very much, and that is the theory of the Big Bang, the theory of the creation of the universe. So my talk is the Big Bang. You'll see that I'm going to divide it into three separate lectures today, tomorrow, and then, Lord willing, on Thursday as well.

Big Bang, that's me. Everybody is in the selfies. I know you can see me personally.

But since everybody is in the selfies, I decided I would put a selfie up there for myself as well. So hello, everybody. We're going to look behind the scenes of the beginning of the universe, which goes under the rubric of the Big Bang.

And what's interesting is that even though we use that now, it was actually used as a pejorative term by Fred Hoyle, who did not believe in the Big Bang. But interestingly enough, more and more evidence now comes to play to show that what we call the hot Big Bang really is the best explanation for the creation of the universe that we know. So what we're going to do in these lectures, like this fellow in the woodcut, we're going to peek behind the scenes and take a look at the science that enables us to understand what the origin, the history, and the future of the universe might be.

And it is not a theory. It is based on very good science that we know about. So the outlines of the talks are going to be the following.

First of all, I'm going to talk about the expanding universe, the redshift. And I suspect most people know that the universe is expanding. This is probably the one part of the Big Bang, the one piece of evidence that most people know about.

But there are also other things that support this particular theory as well. The other is the cosmic elemental abundance. And what is interesting is the Big Bang makes predictions of what elements we should see created during the Big Bang, during the creation of our universe.

And so what we're going to do is we're going to look at the ratio between helium and hydrogen, deuterium, another form of hydrogen, and regular hydrogen. And we're going to see if the Big Bang actually predicts these ratios. And then the other thing that we're going to do is take a look at the cosmic background radiation.

With antennas, we can look anywhere in the universe. And what we find is the universe is bathed in radiation, is bathed in radio waves. And what is interesting is those radio waves really come from the creation of the universe.

And those are the three pillars upon which we're going to base our understanding of what is happening. But there are some problems. In the third lecture, we'll deal with that.

Again, Lord willing, the so-called horizon problem, the flatness problem, and really how that leads to the possibility of a multiverse. And finally, we'll have some conclusions and some theological reflections on all this. So welcome to CSI.

CSI, Crime Scene Investigation. This, however, is going to be a cosmology science investigation that we are doing here in these lectures. And like crime investigators, what do they try to figure out when they come upon a crime scene? Who, why, where, when, and how did all this occur? Well, we already know some things about the universe.

And here is where my Christian faith comes in and my belief in the biblical material. First of all, who? Well, God himself, the God of the Bible. In the beginning, God created the heavens and the earth.

And for a long time, people denied that that could be the case. But I think we can make a case that at least there are indications when we look at the Big Bang that this could be the case. Why? For his glory.

We find this in Psalm 19, verse 1. For the heavens declare the glory of God and the firmament his handiwork. So he does it for his glory. When? Well, here, not everybody agrees in Christian circles.

But the scientific evidence strongly points towards a creation of this universe that was roughly 14 billion years ago, literally more close to 3.8. All right, 3.78 plus or minus 0.002, if you like. But let's just call it, we're among friends. Let's just call it 14 billion years.

Where did this occur? Well, all over. We're talking about the universe. We're talking about everything that we see for creation.

And then how? That is what we're going to concentrate on in these lectures. How did this occur? What are the physical processes by which we have the universe that we now see? And that is known as, I mentioned, not just the big bang, but the hot big bang. The universe at one time was much hotter than what it is now.

And that is what leads to a lot of the observables that we have at this time, even though the universe was created some 14 billion years ago. What's the evidence supporting the big bang? Actually, there are three pillars. And as you can see by the photo, I just came back from Greece.

So these are the three pillars supporting the hot big bang, shown as the lintel. The first is the expanding universe, which I already mentioned. The universe was smaller.

And it's going to get bigger than what it is now. The second is going to be the light elemental abundance. I already waxed long on that, so I won't say too much more.

But again, the hot big bang, the theory of the hot big bang, leads us to understand cosmic abundances of elements that we see, that we observe, as we look out into the outer parts of the universe. And then finally, the cosmic background radiation, as I mentioned. Our universe is bathed in the remnants of the hot fireball that we had when the universe was formed.

And all of this, of course, is based on known physics. And you know, that is what is just so fascinating about this. We have physical laws that we can test and understand here on Earth.

And we take those physical laws, and we apply it to the outer reaches of the universe. And lo and behold, if we can build a tapestry where everything works together and understand what's going on in the whole universe by what we know here to be true on Earth. We test physical laws here, we apply them to the universe, and we understand what's going on.

This is absolutely amazing when you stop to think about it. Well, hopefully, I'm not going to give people a headache with the discussion. But I'll try to keep it understandable.

And we'll try not to do the following. Sidney Harris is one of my favorite cartoonists. And I asked him if I could use this particular cartoon, and he granted me permission to use it.

So I don't know if you can read it, but tell us in layman's terms what your theory means. Certainly, and we get a bunch of mathematical equations; I will avoid this. But pillar number one, which we'll spend the rest of the time today discussing, is the expanding universe.

How do we know the universe is expanding? How do we know that it was smaller at one time than what it is now? How do we know that it's going to get bigger? If it's expanding, it's going to get larger. And this particular graph, I will explain. It overlays pictures that we've gotten from the Hubble Space Telescope of very distant galaxies.

Let's do some history. Back around 1912, Vestal Melvin Slipher was a graduate student. And he wanted to check the rotation of a group of stars that we call galaxies that look like this.

This is the Andromeda galaxy. It's about 2 plus million light-years away from us, which, by the way, means that it's going to take about 2 and 1 half million years or so for the light to reach us that is emitted from the galaxy. I'll get into that later.

But basically, what he wanted to do is check the rotation of these groups of stars, because everything in the universe rotates. The Earth rotates. The Earth rotates around the Sun.

The Sun rotates. Our galaxy, the Milky Way that we are in, rotates. Everything rotates.

And what he wanted to do is to check how fast these groups of stars, these galaxies, were rotating. And he used a method of doing this called the Doppler shift, which I will get into shortly. But as he was trying to take his measurements, he noticed something very interesting.

All the galaxies that he was looking at were moving away from us. I'll explain how he knew that. But all the galaxies were moving away.

Well, he went to his advisor and mentioned that the five or so galaxies that he had measured all had a redshift again. Hang on to that. I'll explain that.

All had a redshift, meaning they were all moving away from us. And his advisor says, well, maybe it's a selection effect. Why don't you go check a few more galaxies? And so he went and checked three or four more galaxies.

Lo and behold, they were all moving away from us. Now you say, so what? You've heard preachers. What they'll do is they'll tell you what they are going to say.

They'll say it. And then they'll tell you what they said. Well, the listener, the congregant, also has a three-point sermon.

Who cares, so what, and what difference does it make? So here's the who cares, so what, and what difference does it make? What difference does it make is the following. This is the milieu in which astronomers and physicists were operating at this particular time, and that is the universe is of infinite expanse. It doesn't change.

You have it filled with galaxies that are moving around randomly, and nothing changes much. Now, the shock that came from Slipher's measurements, as a result of Slipher's measurements, that all the galaxies were moving away, raised questions, because if you are in the kind of universe that they thought was around at that time with random galaxies moving randomly, what do you expect? When you look out randomly at galaxies, you would expect half of them to be moving toward you and half of them to be moving away from you. Here's an analogy.

If you could look at all the gas molecules in this room, they're moving randomly. So if you were to have a line of sight and just randomly check molecules in that line of sight, you would find half of them moving towards you, half of them moving away from you. If all of a sudden you found all the gas molecules moving that way, you figure somebody's turned on a fan over there.

There's something going on that's weird. And so the fact that all the galaxies that he was measuring were moving away from us really caught people's attention. In fact, he gave his results at an American scientific meeting, the Astronomical Society of America.

I get AAS and ASA mixed up. The American Astronomical Society meeting back around 1912, and after he gave his lecture, people stood up and clapped, but nobody understood what was going on. Except for one person, Edwin Hubble, and we'll get to him.

Yes, the same person that the telescope is named after, Edwin Hubble. Well, I mentioned the redshift. I mentioned we can tell how objects are moving towards us or away from us.

How in the world? Well, here is a nice, somewhat corny video, but because it's corny, you will remember it. Most scientists believe that our universe is expanding. That belief is based on an interesting property of light waves called the Doppler effect.

Here's how it works. All waves travel outward from a source. A stone dropped in a pond, for instance, will produce waves that move out in a circular pattern from the splash.

Light works the same way. When a camera flashes, light waves move out from the flashbulb. When the source of a wave is stationary, the waves can be thought to form circles radiating out from the source.

But when the source is moving, something very interesting happens. The waves ahead of the moving source are bunched closer together. The waves trailing behind the moving source are spread out.

We hear this effect when a moving car blows its horn as it passes us. We hear a high-pitched sound as the car approaches us because the motion of the car bunches the sound waves closer together. When the car passes us, we hear a distinct drop in pitch because the sound waves are now spread out by the car.

Light waves show a similar shift. If a source of light, like a star or a galaxy, is moving toward us, the light waves are bunched together. And we see the light with a slight bluish tint.

If the star or galaxy is moving away from us, the waves are stretched out. And we see a reddish shift in the color. Because all galaxies show a red shift in the color of their light, this is evidence that they're moving away from one another.

So the red shift is evidence that our universe is expanding. That may be the only thing you'll remember from this lecture, is that corny video. Let me just mention one thing, however.

We mentioned all galaxies are moving away from us. Not all galaxies are moving away from us. And that means not all galaxies are redshifted.

And the reason is that gravity holds some galaxies together in a way that even though the universe is expanding, the galaxies themselves are gravitationally bound together. And so they will not move away from one another. In fact, if you take a look at the Andromeda galaxy that I mentioned earlier, it actually has a blue shift.

It is moving towards us. And it will interact with our galaxy, oh, in about 2 billion years. Now, that's very interesting.

Because once I said 2 billion years, and somebody got very exercised in the audience, how long is that going to take? And I said 2 billion years. You had me worried. I thought you said 2 million.

At any rate, the Andromeda galaxy, for example, is moving towards us. Other galaxies are swarming around the Milky Way. We have about 20 some galaxies moving around our own galaxy.

Our own galaxy is really a giant. And those galaxies are not going to move away from us. On the other hand, once you get beyond about 250 million light-years, all the galaxies are moving away from us at that point when you get out to that distance.

Which, of course, if I'm saying distance in light-years, we have to explain what a light-year is. It sounds like a unit of time. It's not.

It is a unit of distance. It is the distance that light moves in one year. And if you take 186,000 miles per second times 60 seconds times 60 minutes to an hour times 24 hours in a day times 365 and 1 1⁄4 days in a year, it turns out to be slightly less than 6 trillion miles.

Now, 6 trillion has a lot of zeros after it. So instead of writing how many trillions of miles objects are away, what we like to use is the term light-year. Or astronomers also use another unit called the parsec, but we're not going to worry about that.

So that's what we mean by a light-year. So if I'm looking at an object that is 2 million light-years away, I am not observing that object as it is now. I'm observing it as it was 2 million years ago.

If I observe an object that is a billion light-years away, which, by the way, we can do, a billion light-years away, that means it took light a billion years to get here. We're observing the object as it was a billion years ago. Well, how are we going to figure out what's going on earlier in the universe? You just look out farther and farther and farther.

The farther out you look, the earlier in the history of the universe we are looking. And with that, we can build up a history of what the universe looked like as we go farther and farther out with our observations. And what we find, as I'll discuss later, things change.

Not only is the universe expanding, but how galaxies form and how they change, we also learn that as well. So during the time that Slipher was working on the redshift, interestingly enough, around 1915, Albert Einstein was working on a theory of relativity to try to understand the origin, the history, and the future of our universe. He had already, in 1905, worked on what is known as the special theory of relativity.

But then in 1915, he worked on the general theory of relativity. What is the difference? The difference is that the first theory did not involve gravity. And gravity is your major force when you're dealing with the universe.

So he had to move gravity into his special theory, and came out with what's known as the general theory of relativity. And these are the equations. Actually, this is one equation.

But when you break down all these indices, there are 16 equations here. One side discusses the geometry of the universe. And this will make more sense later.

The other side discusses all the matter and energy of the universe. And this was his genius, to be able to correlate the geometry of the universe with how much material and how much energy is there. But he ran into the same problem that Slipher was running into.

And that is, what is happening to the universe? He was in the milieu that the universe was infinite in extent, and nothing really changed. And he looked at his equations that did not have this factor, lambda factor, that I've circled. And he said to his whores, the universe could not remain static.

It either had to compress or expand. Well, this was just totally against what the common idea was about what nature was like. And so he added this term, the so-called lambda term, in order to keep the universe from expanding.

And wiped his brow and says, OK, I've taken care of that. More later. Unfortunately, a Belgian priest by the name of Georges Lemaitre, a Dutch mathematician astronomer by the name of Willem de Sitter, and a Russian meteorologist by the name of Alexander Friedman took Einstein's equations, even with that lambda term.

And guess what? You cannot have a static universe. It either expands or contracts. Einstein was astounded.

And we'll see one of his reactions later on. But during this time, in the late 20s, early 30s, a man who took Slipher's measurements seriously by the name of Edwin Hubble decided to advance the observations of Slipher. And he and his sidekick, Milton Humason, who, by the way, was a donkey.

What do you call somebody who trains donkeys? A mule, and mules, et cetera. Basically, he started bringing material up to the Mount Wilson Telescope in California. And he got so involved with what was going on that Hubble was doing that he had joined him and eventually was starting to do the work that Hubble was doing along with Hubble, interestingly enough.

So if you are training donkeys or mules, there's hope for you. But the Mount Wilson 100-inch telescope eventually was abandoned, not abandoned. But Hubble began to work with the Mount Palomar Telescope.

And the telescope, to give you how big this is, this mirror is five meters across, about 200 inches. This is a 200-inch telescope. And light comes in from the top, comes down to this curved mirror, bounces up to a cage here that you can actually see in this view.

And the telescope is so big that Hubble could actually sit there in the cage and take photographs of galaxies. But he didn't just take photographs. He took spectra of galaxies.

And here's what that means. We have light coming in from one place through some kind of an opening to something that will break up the light into its various colors. And we call that a spectrum.

I'm using a prism here for illustration. Well, you can also use what's known as a diffraction grating. But the idea is you take the light that comes in, and you break it up into the spectrum because the spectrum shows numerous things about the source.

I've already mentioned one. Is it going away from us? Or is it coming towards us? And how do we know? Because, for example, we know what the spectrum of hydrogen is when it is heated up here on Earth. We get a spectrum.

Now we look at the same element coming from a galaxy. And if it's shifted to the blue, the galaxy is coming towards us. If it's shifted to the red, the galaxy is moving away from us.

But it's not just the motion of an object that we can see from a spectrum. We can also tell what material is there and how hot it is. The spectrum turns out to be one of the major means of being able to understand what is going on in the universe.

So we get a spectrum. This is what it looked like back then. It used to be on small glass plates.

And to take a good spectrum sometimes would take several nights to make a good spectrum. And this is what it would look like. The galaxy up on top, the calibration line is down below.

So you can tell whether the galaxy is moving towards us or away from us. And what we want to take a look at specifically is these double lines that we find here. They are over in this particular spectrum over towards the blue part of the spectrum.

But now something very interesting happens as the galaxies were examined by Hubble. And notice what happens to the double lines. Notice how they shift over to the red side of the spectrum.

And notice the distances. Here is the first one: 50 million light-years. And the object is traveling 750 miles per second.

And I've changed that to miles per hour. This is slightly faster than people driving on 128. But here's the interesting thing.

Notice that as the distance increases, the shift to the right increases, the shift to the red increases. And so what we have here leads to what is known as Hubble's law. And Hubble's law is the following.

It can be shown with almost a linear graph where you have distance along the bottom and velocity, the vertical axis. And what it means is the farther out the object is, the faster it is moving. Now, interestingly enough, you can use this in reverse as well.

Once you have this relationship built up, you can look at a galaxy that may be so far away that regular means of measuring the distance don't work. You can look at the recession velocity, go to the Hubble graph, and see how far the object is. So this can go both ways.

It is an extremely important graph. I mentioned: notice the linearity. In other words, you can almost put a straight line through all these points, observations.

When you get up to very high distances, however, look at objects very, very far away, the graph begins to bend. And whether it curves up at that point or curves down at that point is very, very indicative of various aspects of the universe. What does it indicate? You're going to have to come back Thursday to see that.

Here's Hubble's law. The greater the distance to a galaxy, the faster it recedes. Or the greater its redshift, as predicted by the analyzers of Einstein's general theory of relativity; they discovered this would happen, and this is what Hubble discovered.

And that is Hubble's law. That basically, the farther the object, the faster it moves. Once you get beyond about 250 million light-years.

Now, I mentioned it takes days. It took days back then to get a good spectrum of a faint galaxy that was far away. Today, we have the Sloan Digital Sky Survey.

We have telescopes that take numerous spectra of objects every single night. And that, along with the Hubble Space Telescope and other satellites that we have, now we have the spectra of millions of galaxies. And we can fit that to Hubble's law very precisely and get exact parameters for how things are moving.

This is the deep field view of the Hubble Space Telescope, where they looked at a, quote, empty part of the sky. And they took a long photo with the Hubble Space Telescope. And this is what they got.

Every one of those points that you see, except this bright one on the lower left, is a galaxy. And if you look at the fainter galaxies, you would think they are farther away. And indeed, they are.

And the farther away they are, the faster they move away from us. That is the indication that the universe is expanding. Those are the data that we base this on.

How would Einstein react? He went to Mount Palomar. He met with Hubble, looked at his data, looked through a telescope. And lo and behold, he began to believe that the universe was expanding.

As for the cosmological constant, remember what I said? He put in this, quote, fudge factor in order to keep the universe from expanding. And then it turns out it does anyway. Parenthetical remark.

That is an unbelievably important factor in our understanding of the universe today. Stay tuned. One of the initial theorists to work with the Big Bang- he did a lot of work both for the cosmic background radiation and for the elemental abundance- was George Gamow, Russian.

Back in 1965, actually, it was the spring of 66 when I was going back to Beloit College. I graduated from Beloit College before going to Cornell. He actually came and spoke.

And it was very interesting to hear him speak and to greet him. Brilliant, a bit eccentric, but brilliant. And he writes the following in his autobiography called My Worldline.

He said, much later, when I discussed the problem with Einstein- that is, the expanding universe- he remarked to me that the introduction of the cosmological constant, that lambda that I had shown in the equation, was the biggest blunder he ever made in his life. But this blunder, rejected by Einstein, is still sometimes used by cosmologists even today. I wouldn't say used now and then by cosmologists.

It is essential right now for modern cosmological theory. And the cosmological constant denoted by the Greek letter lambda rears its ugly head again and again and again. Well, that was what they thought back then.

But now, as I said, this becomes essential in understanding what is going on. Well, why is this the case? How can we explain this? What's an example? Here is where astronomers use the classic model of raisin cake. All right, here's where we're going to do a bit of mathematics.

I guarantee you, you will not need your calculator, so you put your phone away. But here is a raisin cake that has been put together. And what happens when you get astronomers in the kitchen and you have a raisin cake, they begin to measure distances between raisins.

And so here are some illustrations. We have a couple of raisins, A and B, that one centimeter apart, which is the upper left here. And then we have A and C, five centimeters apart.

And then we have A and D that are 16 centimeters apart. After an hour, we bake the cake, and it expands by a factor of 2. Now we take a look at the distance between the raisins. Remember, A and B were one centimeter apart.

Now it's two centimeters apart. Here's your math quiz. What was the speed of separation of the two raisins in terms of centimeters per hour? I know people have trouble with math, but really.

OK, two centimeters minus one centimeter, one hour. It moved at the speeding rate of one centimeter per hour. Now look at A and D. They were 16 centimeters apart.

Now they're 32 centimeters apart. It moved 16 centimeters in one hour. The speed was 16 centimeters per hour.

Notice the farther they were to begin with, as the dough expanded, the faster they moved, the farther they moved apart. Now, if you were on a raisin looking at the other raisins, you would see them redshifted if those raisins are galaxies. Now here is the interesting thing.

Notice the raisins are not moving through the dough. How are they separating? It is the dough that is expanding and pulling the raisins with it. And that is exactly what is occurring in the universe.

The galaxies that are receding from us are not moving through space as they recede from us, but rather spacetime itself is expanding like the dough and pulling the galaxies with it. And that is the model to use. Now interestingly enough, whatever equation you use to find a Doppler shift where objects are moving in space, the same equations pretty much apply when you talk about a recession as a result of spacetime pulling the galaxies apart.

And that, as I said, has become kind of the time-honored view. Well, what does it mean? Let's run this backward. Here's how we have galaxies.

They were closer together. Times pass. Even earlier, they were closer together.

And then at one time, everything that we see- you, me, this room, Gordon College, the Earth, the sun, the galaxy, everything that is visible to us and invisible to us that was part of the universe was together as a single point, smaller than the size of a proton. Contemplate that. Of unbelievable density, of unbelievable energy, of unbelievable heat.

And it's out of that that arose what we see by processes that we will mention earlier. It's hard to believe now. You can imagine what people felt like then.

Big bang, not big bang. Well, let me do some concluding remarks of Hubble's law and the expansion, the big bang. The universe is expanding.

And this is naturally explained by the Big Bang. No special setups here. This means the universe had a beginning.

And I would suggest a beginning. Third, the rate of expansion indicates that the universe began about 14 billion years ago. All you need to do is remember the linear Hubble relationship. All you know is take that slope and go back.

And with some adjustment of the models of what kind of a universe we live in, basically what it shows is that the universe started about 14 billion years ago. By the way, it's not just this slope of this line that gives us those results. What also give us those results is studying the cosmic background radiation.

And I'll get into that tomorrow. But a good date right now is about 13.78 billion years ago we had the beginning. Does this relate to the Bible? Well, I already mentioned initially.

In the beginning, God created the heavens and the earth. I also mentioned Psalm 19: the heavens declared the glory of God. But here are some very interesting verses that we find in Scripture as well.

And these were brought out to me by our president at Biblical Theological Seminary, where we were, Alan McRae. And he thought they were very interesting. The first one comes from Job, chapter 9, verse 8. Job is talking about the Lord.

And he says, who alone, that is the Lord, stretches out the heavens and tramples down the waves of the sea? Stretches out the heavens, or is stretching out the heavens? It's present tense. Well, that's interesting. OK, that's one verse.

Let's try another one. Isaiah, Isaiah chapter 40, verse 22. It is he, again, the Lord, who sits above the circle of the earth, probably implying the horizon.

Now, some people translate it as the sphere of the earth, meaning that there might be an indication of sphericity to the earth. I think that just saying it's the horizon is enough because it looks like a circle, right? You go around and take a look at the horizon. He who sits above the circle of the earth and its inhabitants are like grasshoppers, not very flattering, is it? Who stretches or is stretching out the heavens like a curtain and spreads them out like a tent to live in? You've all put up a tent, I'm sure, sometime.

What do you do? You put up the poles. You spread it out. You put another pole here.

You spread it out. You put another pole there. Is it interesting that that is the term that is used? Not God created the heavens.

He stretched out the heavens. He is stretching out the heavens. Couple more, Isaiah.

And by the way, this is in the 40s of Isaiah, the chapters 40s of Isaiah, where the emphasis that Isaiah is making at that point is who God is, the power of God, what he's done, what he's going to do. And it's very interesting that it's in this group of chapters that you find these verses. The Lord is speaking here.

It is I who made the earth and created mankind upon it. I stretched out the heavens with my hands, and I ordained all their lights. What lights? The sun, the moon, the stars that are mentioned both in Genesis and later on in Psalm 148.

So again, you get the idea that what he's talking about is the heavens, where the stars are, where the lights are. Again, the idea of stretched out. It doesn't say I created it.

I stretched it out. And let's try one more, Isaiah 51:13. You have forgotten the Lord.

This is a rebuke to the people of Israel. You have forgotten the Lord, your maker, who stretched out the heavens and laid the foundations of the earth. Fascinating, isn't it? Now you're going to say, Perry, Perry, Perry.

I mean, come on, really. What did it mean to the people back then? What did it mean to the people back then? Why would he use the word stretch? How would they understand it? These people, for a while, lived in tents. They knew what it was like to spread out a tent.

And they're looking at the sky and say, well, maybe I don't understand exactly what he's talking about. But you know something else? Scripture tells us that the prophets who prophesied about Jesus, many of them, they prophesied, but they didn't know how it was going to turn out. In other words, they didn't always know exactly what was happening.

It took us, in this age, with the New Testament, to see how some of these things worked out. And some of these things, we're going to have to wait in the future to see how they work out. Could it be, just a suggestion, could it be that here we have a little nugget in Scripture that we understand now, when we understand the expanding universe, that we understand the Big Bang, now, when so many people deny the whole premise of a God that exists, or the whole premise of an inspired Scripture, is it an interesting that maybe it's now that we understand this, that is an indication that we have been communicated by the God that lives in His Scripture? Just a suggestion.

Well, we've looked at the first pillar. I said this was the expansion of the universe. This is Hubble's Law, also, Hubble's Law expansion, similar terms.

Lord willing, tomorrow we'll look at the light elemental abundance and the cosmic background radiation. And then Thursday, we will mention some of the difficulties that are solved by not just the hot Big Bang, but the inflationary hot Big Bang, which, of course, fits in right well with the inflation that we're experiencing today. So last two points, and with this, I will quit.

Everybody who believes in the Big Bang, everybody thought that the time would come when eventually gravity would slow down the expansion and the expansion rate would slow down. It makes sense. This is what happens here on Earth.

You shoot something up into the air; you throw a ball up in the air; it goes up so high, stops, turns back down. If gravity is strong enough, it will do that. If you throw a ball up in the air with enough of a velocity to escape from Earth, that is beyond the so-called escape velocity; the ball keeps going and going and going.

Then there's a very critical velocity, a very critical speed at which you can throw an object in the air that will escape Earth, but just barely. A very, very critical trajectory. The ball keeps going, but it slowly keeps slowing down, slowing down, slowing down, et cetera.

And that's what these curves indicate that we find here on this particular graph. For reasons that I'll mention later, a universe where gravity is so strong that it comes back down on itself is called the closed universe. And the idea is the universe expands so far, stops, and starts contracting.

Instead of a big bang, you have a big crunch. The open universe is where the velocity is so great that the universe just expands and expands very, very quickly. And then you have what's known as the critical expansion.

If you like, the expansion is right at the escape velocity, if I may use that term. Everybody expects it. It's going to be one or the other.

I mean, it makes sense, right? You've got gravity. The universe is a big place. There's a lot of material.

Gravity eventually is going to start drawing things together. Unfortunately, here's what we find instead. Gravity slowed things down up until about 10 billion years ago, 9, 10 billion years ago.

And now the investigations show that the rate of expansion is increasing, contrary to what we would expect from gravity. It is accelerating. And it appears that the universe is filled with something called dark energy.

It's also filled with something called dark matter, which I will discuss at a later time. But this is very interesting. And it was a shock that came to everybody in the late 90s.

I'll end with this. One of my other favorite cartoonists is Randy Glasbergen. I don't know if you can read it, but it's says, we've done a thorough analysis of our situation and have come to the only logical conclusion.

The universe finds us amusing and keeps us around for laughs. And there's the universe laughing at us. Thank you very much.

Thank you. We have about 10 minutes or so for questions. So there are some mics, which will be floating around.

We'll gather your thoughts, which are going to be blown apart by the time we go in. And we'll have a few questions. Hello.

First of all, thank you very much. That was a lovely presentation. My question is on the origin of the Big Bang.

So I've heard different analyses on how the Big Bang actually occurred, one being that it came from a singularity. Given that nothing can escape from a singularity or from a black hole, how is it that the Big Bang would have originated from a singularity? If you could just expand on that? Yes, thank you. How do we originate from a singularity when the singularity really implies infinite density, et cetera? The understanding of the Big Bang really does not start at what I would call time t equals 0, which would be a singularity.

The farthest back we can go and the furthest back we can go in time is what is known as the Planck time, which is 10 to the minus 43 seconds. And a Planck distance, then, which is about 10 to the minus 33 centimeters or so. And so we start from there.

Because before that, we don't have the physics to understand what's happening. Because then you have to take general relativity and fuse it with quantum mechanics, which is a study of very, very small things. And nobody has done that yet.

Strength theorists are working on it, but they've been working on it now for 30 years. And the best they can come up with is we have about 10 to the 500th solutions as to how the Big Bang might have begun. 10 to the 500th, I mean, that blows your mind, right? It's one with 500 zeros after it, and we don't know which one it is.

So we don't even worry about that for the most part. But you don't start with a singularity. And you start with time after the Planck time, when at that point, the physics that we know, that we understand, we can start studying the universe at that point.

By the way, let me just mention, I'll get into this more. A number of the elements that were formed were formed when the universe was very hot. And I'll explain how that happened when the universe was very hot.

And we know at what temperature those elements would form, and those particles would form, like quarks and gluons, et cetera. And what is fascinating, this is about 10 to the minus 13 seconds. I know I throw these numbers around like an astronomer.

10 to the minus 13 seconds after the Big Bang, we know what particles should be forming. And we can show that that is the case with particle accelerators here on Earth. The Large Hadron Collider, for example, accelerates protons against one another, beams of protons.

It's very, very high energy against one another, and smashes the protons together. And you get all sorts of particles that form. But you also get a plasma that is very hot that matches the temperature that we would find in the Big Bang after 10 to the minus 13 seconds.

And guess what? They correlate, which is pretty amazing. And here's a point where you can take a look at atomic physics, nuclear physics, quantum mechanics, and apply it to the universe as a whole. But the main thing to answer your question, you start after the singularity.

Once you have a theory that proposes a singularity, once you have a theory that proposes an infinity, or depends on an infinity, in order to progress, there's something wrong with the theory. Because infinity is not just a large number. To quote George Ellis, infinity is not just a large number.

It's an unattainable state. And people, blasé, say, well, the universe has been around for infinity. It's going to go on for infinity.

No, no, this makes no scientific or philosophical sense to me. How's that for a very long answer to a very short question? Yes, next, please. Thomas.

For the Andromeda galaxy to have a blue shift, would that mean it is closer to, I guess, the center of the universe than we are? Or is it parallel? Or I guess my question is, how can any galaxies show a blue shift if we're all radiating out from, presumably, a central point? Yes. In terms of the Andromeda galaxy, it is gravitationally hooked into our own galaxy. And that's what keeps it from spreading out.

And when they collect, by the way, don't think when they collect it's going to be like two stars that crash, two cars that crash. A galaxy, in spite of all the stars that we have, is basically empty space. And what you'll have is one galaxy will pass through the other.

Some of the gas clouds will interact and form new stars and planets and what have you. And then they'll go out and then begin their dance around one another as they are now. I may have a really brief follow-up.

Are we appearing as a blue shift to all of the galaxies that we see as redshift? I didn't hear the first part. Oh, to all the galaxies that are further out from us that we see as having a redshift, if we were there looking back upon the Milky Way, would it have a blue shift? No, no, no. Going back to the raisin cake model, whatever raisin you are on, every other raisin is moving away.

Again, if your raisin cake is big enough, like 250 million light-years. Now, the raisin cake model falls down because you have an edge. You have the pan that you're baking it in.

Whereas in the universe, there's really no edge. And maybe the best way to think about that is a two-dimensional analogy. And with this, I'll end for the sake of time.

Think of being on the surface of a balloon, and you have little dots on that surface of the balloon. Now, you are stuck in two dimensions. You can't look to the center.

You can't look out away from the center. You are stuck to the surface of the balloon. You're totally two dimensional.

And then the balloon is expanding. And you're on there. And every one of those dots, no matter where you are, is going to appear to be moving away from you.

There's no edge. That's what I'm trying to say. There's no edge to the universe.

However, there is a horizon. And what's that horizon? I mentioned the universe is expanding. The farther out we go, the faster it's expanding.

Eventually, it's going to reach the velocity of the speed of light. What? I thought nothing went faster than the speed of light. What are you talking about? Nothing goes faster than the speed of light in space.

But spacetime itself can expand faster than the speed of light. And once you get to that point, once you get to that distance, sayonara. Goodbye.

It's been great knowing you. We'll never meet again. And with that, we'll end.

Thank you very much.