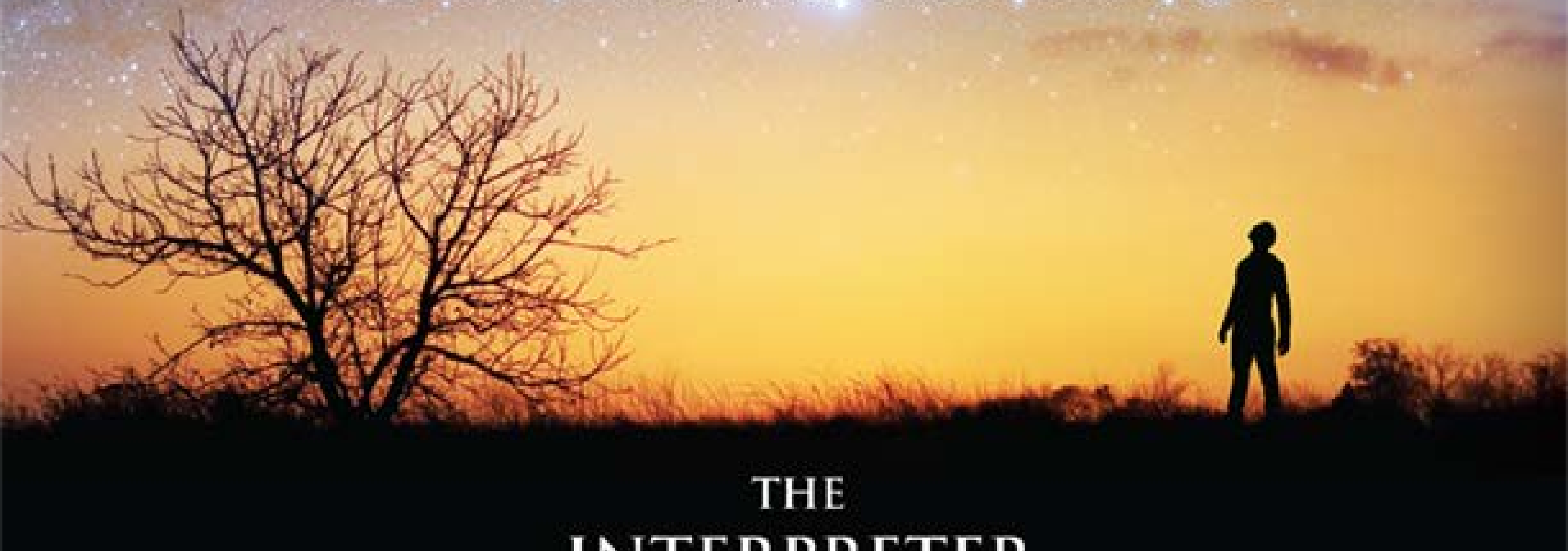
Science & Mormonism Series 1: Cosmos, Earth, and Man

Chapter Title: Joseph Smith and Modern Cosmology
Chapter Author: Ron Hellings

SCIENCE & MORMONISM SERIES 1

COSMOS, EARTH, AND MAN

DAVID H. BAILEY, JEFFREY M. BRADSHAW, JOHN S. LEWIS, GREGORY L. SMITH, AND MICHAEL R. STARK



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SCIENCE AND MORMONISM 1: COSMOS, EARTH, AND MAN

David H. Bailey, Jeffrey M. Bradshaw, John S. Lewis,

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JOSEPH SMITH AND MODERN COSMOLGY

Ron Hellings

The goal of this chapter is to take a look at some of the teachings of Joseph Smith that seem to have cosmic implications and to try to understand these in light of modern cosmology.

Modern Cosmology

Let me begin by stating that this is an extremely exciting time to be doing cosmology. In the last thirty years, we have learned so much about the universe that we are now completely mystified and profoundly confused. We understand less than five percent of the content of the universe — atoms and molecules and fields and radiation and all of the other things we know. The rest, ninety-five percent of the content of the universe, is completely unknown. Twenty percent of the universe appears to be what is called *dark matter*. We know several things that dark matter is not, and we still have a few ideas about what it might be, but we do not know what it is. But dark matter, at least, acts in a way we understand. The remaining seventy-five percent of the universe must be something for which we don't even have very good ideas. It is something called *dark energy*. Whatever dark energy turns out to be, it's going to require a revolution in our understanding of physics.

The simplest way to explain the dark energy result would be to reinstate Einstein's cosmological constant and give it just the right value to have the effect we need. This is somewhat like having a theory that says 2 + 2 = 5 and saying that it's a great theory as long as you agree to subtract 1 from the answer. Another possibility is that the dark energy is actually a quantum mechanical vacuum energy density. The only problem here is that when we calculate what that energy density should be, we get an answer that is 10^{120} times too big. Even in astronomy, it's tough to get an answer that's *that* wrong. So, many people feel there is just some new dynamic fluid out there that we don't otherwise know about. They have given it a name; they call it "quintessence." It makes up seventy-five percent of the universe, and there

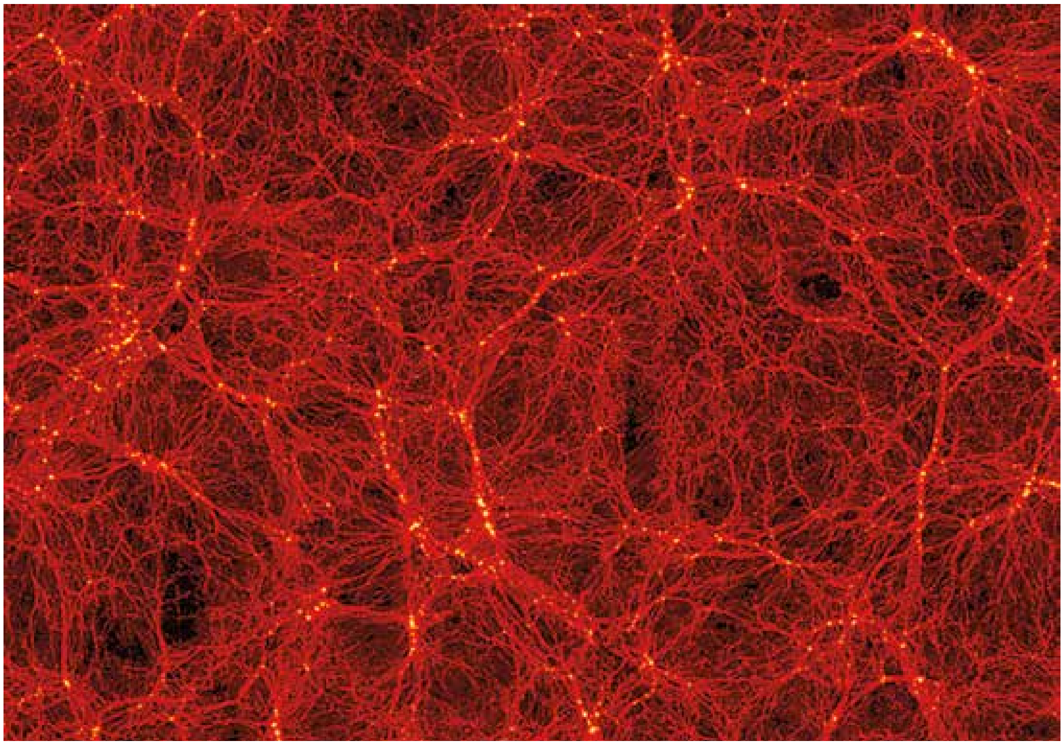

Figure 1. *Result from the Bolshoi Simulation of Structure Formation in a Universe with Dark Matter and Dark Energy*

are lots of heuristic models used to describe it. But it has to be a very strange stuff. It has to have a negative pressure as its equation of state, and no normal energy or matter can do that that. So finally some have suggested that Einstein's theory of general relativity, his gravitational theory, is fundamentally wrong and will have to be replaced. Whatever happens, there is going to be a radical change. Ideas that would have labeled someone a crackpot ten years ago are now being published in the finest journals. And everyone, as I said, is quite confused.

One of the things that I did when I was at the National Aeronautics and Space Administration Headquarters was to serve as the NASA representative to a group that NASA, the National Science Foundation, and the Department of Energy had put together called the Dark Energy Task Force. Their goal was to discuss the dark energy problem and to advise the agencies about the best ways to go forward to work it out. When I went to their meeting the first time, I saw a lot of people I knew and a lot of people I didn't. At the first coffee break, I got something to eat and came back and sat down at the table. Then I noticed this little knot of people sitting at one end of the table and talking. One of them was holding forth on Mormonism. It turns out that, just the weekend before, *Time Magazine* had come out with one of their regular articles explaining Mormonism to the world, and this guy was explaining about the Church and about how silly some of the Mormon doctrines were. I had just gotten to the point where I was thinking I should get up and go over there and say something when they called the meeting to order again. One of the guys who had been in the group, a guy I knew, came over and sat down next to me, and he leaned over and said, "You're a Mormon, aren't you?" And I said, "Yes I am. And I've got to tell you I think it's ironic for a member of the Dark Energy Task Force to be ridiculing anyone else's beliefs."

They say you should start a talk by stating your main points, and so here's one of my main points: This is no time for anyone to be criticizing anyone's beliefs based on what cosmologists know.

Lord Kelvin on Physics

There is another point I would like you to take away. I hope you'll remember these next two thoughts. In the years leading up to the start of the 20th century, British Physicist Lord Kelvin is reported to have said:

> There is nothing new to be discovered in physics now. All that remains is more and more precise measurement.[1]

First, let's be clear about one thing: Is he right? No. This is absolutely not a correct statement. So how could he have said this? Maybe you might think he wasn't very smart or didn't know much physics. Who was Lord Kelvin? We name our absolute temperature scale after him. He did marvelous things in electricity and thermodynamics; he was aware of the entire field of physics at the time; he was one of the brightest physicists around. So here's a question you need to ask: How could he be so wrong? How could someone who knew that much come to this conclusion, which was so obviously wrong?

Joseph Fielding Smith on Space Travel

While you're pondering that, let me give you another quote. This is Joseph Fielding Smith in 1957:

> It is doubtful that man will ever be permitted to make any instrument or ship to travel through space and visit the moon or any distant planet.[2]

I should point out first that this is not a scientific conclusion but a religious one. This is a conclusion he came to by reading the scriptures, interpreting them, and deciding that earth was for man and the moon was not. He concluded that we would therefore have no business being there. But let's be clear: was he right or wrong? Clearly, he was wrong. Do you know who Joseph Fielding Smith was? Was he someone ignorant of the scriptures or not very smart? Neither of those, right? This was a man who knew the Gospel as well as anyone in the Church at that time. He was a giant in scriptural understanding and interpretation. And so the other question you need to be asking yourself is this: How could he be so wrong?

As you're pondering that one, let me give you a quick quiz question here.

> If you ever see what appears to be a conflict between science and religion, can you think of at least two places where the problem might lie?

All right, I hope you can answer that question appropriately.

Joseph Smith's Cosmology

Now I want to talk about cosmology and see if there is a conflict between science and our LDS religion in this area. I want to begin by summarizing a few things about Joseph Smith's cosmology. I have two basic guidelines I want to follow as I do this. The first is that I'd like to say something worthwhile, and the second is that I would like to keep the nonsense to a minimum.

Let me explain what I mean by the first goal. It would be the easiest thing in the world for me to stand up here and weasel and waffle and wave my hands and say, "You know, Joseph Smith was speaking in language we don't understand, and we don't know if he was claiming prophetic inspiration for what he said, so we really can't say anything about his views of cosmology." But I don't believe that.

Joseph Smith was an extremely inquisitive man. In March of 1839, he made this most amazing statement:[3]

> Thy mind, O man, if thou wilt lead a soul to salvation, must stretch as high as the utmost heavens and search into and contemplate the darkest abyss, and the broad expanse of eternity — thou must commune with God.

Let me suggest to you that Joseph Smith did commune with God and that, as a result, he did acquire cosmological insights and tried to teach them in his sermons and writings. In this talk I want to take his teachings as much at face value as I can and try to make as much scientific sense of them as I can.

Now, it might be interesting to compare what Joseph said with what contemporary scientists and philosophers were saying. But I don't think that this would really be very useful. Joseph was not a man of science, and I am not convinced that we have any idea what he knew about what others were saying. So it is difficult to make any case for interpreting his statements in light of their language. I do not really want to go in that direction.

But I do need to remember that Joseph would not speak in modern scientific terms. One powerful statement that he made is found in Doctrine and Covenants 131:7:

> There is no such thing as immaterial matter. All spirit is matter, but it is more fine or pure.

Now, unfortunately, he did not say, "All spirit is matter, but it coupleth to a different metric." I wish he had said that because then I would understand what he meant. But he would have no business talking like that in 1840, so we have to speculate a little to see what he might have meant by the language he used.

As I said, the second guideline I want to observe in this presentation is that I want to keep the nonsense to a minimum. Let me tell you what I mean by this. Let me read you one of Joseph Smith's revelations from Doctrine and Covenants section 88:7-11:

> This is the light of Christ. As also he is in the sun and the light of the sun and the power thereof by which it was made. As also he is in the moon and he is in the light of the moon and the power thereof by which it was made. As also the light of the stars and the power thereof by which they were made. And the earth also, and the power thereof, even the earth upon which you stand. And the light which shineth, which giveth you light, is through him who enlightened your eyes, which is the same light that quickeneth your understandings, which light proceedeth forth from the presence of God to fill the immensity of space.

I look at that and say, "All right. Light. I'm a physicist. I know everything there is to know about light. This is light. Electromagnetic radiation, Maxwell's equations.

But when I try to apply what I know about light to Section 88, I realize that I have no idea what Joseph Smith was talking about. He was certainly not talking about normal light. He was not talking science. So "keeping the nonsense to a minimum" means that I am not going to pick up every statement Joseph Smith ever made that seems to have some cosmic content to it and force it into some global theory that I will then attribute to Joseph Smith. I will only consider elements of Joseph's teachings that are relatively unambiguous and that remain consistent over the years.

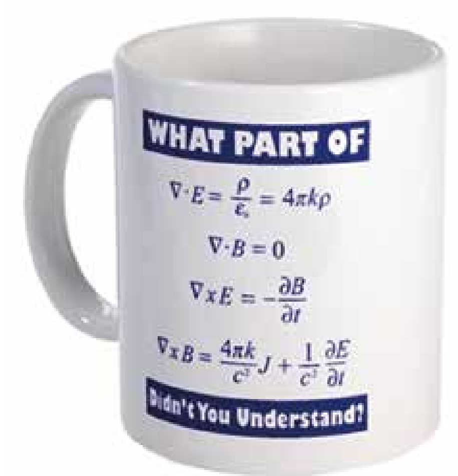

Figure 2. *Maxwell's Equations Mug.* Light is a form of electromagnetic radiation.

So, now, on to the task. Let's talk about three aspects of Joseph Smith's cosmology.

1. Matter Is Conserved

I'd like to read you two statements from Joseph Smith. The first is in 1839. This was something he said to the apostles and seventies as they were going off on a mission:

> Anything created cannot be eternal; and earth, water, *etc*., had their existence in an elementary state from eternity.[4]

The second is from the King Follett Discourse:

> The pure principles of element are principles which can never be destroyed; they may be organized and reorganized, but not destroyed. They had no beginning and can have no end."[5]

"Elementary state" and "pure principles of element." What did he mean by those words? He was trying to express something in the language he had, but it is difficult to make modern sense of it. Was he saying that each atom must retain its eternal character? Modern science has certainly disproved that. Or was he saying that there is something that underlies all elements that is a conserved quantity? That idea holds more promise. We will summarize this general idea, whatever it means

JOSEPH SMITH'S COSMOLOGY

- "MATTER" IS CONSERVED
- EVERYTHING IS MATTER
- THE UNIVERSE IS INFINITE AND ETERNAL

Figure 3. *Elements of Joseph Smith's Cosmology.*

precisely, with the phrase "Matter is conserved." We have left "matter" in quotes and may want to revisit possible meanings for "pure principles of element" later.

2. Everything Is Matter

Here are a couple of additional statements of Joseph Smith: We already read "There is no such thing as immaterial matter" (D&C 131:7). That's in the Doctrine and Covenants. We also saw that "All spirit is matter, but it is more fine or pure" (D&C 131:7). And, finally, we read in the Doctrine and Covenants that "The Father has a body of flesh and bones as tangible as man's" (D&C 130:22). The point here is that whether we talk about the material world, the divine world, or the spirit world, we are talking about real things. One of the characteristics of matter is that it has mass, so everything should be detectable by its gravity. There is nothing intangible or imaginary about the universe. Whatever Joseph meant by "matter," it is clear he meant that nothing else exists. Let us summarize this idea with the statement "Everything is matter."

3. The Universe Is Infinite and Eternal

In one of his last discourses, Joseph Smith taught, "Intelligences exist one above another, so that there is no end to them."[6] If there is no end to the present number of ranked intelligences, then there must presently be an infinite number of them. "Intelligence of spirits had no beginning, neither will it have an end."[7] So there is an eternal existence to those intelligences. And just to remind you: "There is no such thing as immaterial matter" (D&C 131:7). Finally, all of this infinite and eternally existing material stuff has to exist somewhere. "And there are many kingdoms; for there is no space in the which there is no kingdom; and there is no kingdom in which there is no space." (Doctrine and Covenants 88:37). With these statements, Joseph Smith committed LDS doctrine to a universe that is infinite in size because it has to hold an infinite number of real things and eternal in scope because those real things are uncreated and indestructible. The universe is infinite and eternal.

Cosmology 1840-1930

Now let's compare these elements of Joseph Smith's cosmology to the elements of scientific cosmology in the years from 1840 to 1930.

1. Matter Is Conserved

In 1840, Lavoisier's experiments had proven that mass was conserved in chemical reactions. But at that time there was not yet much interest in the concept of energy. It wasn't until later that heat was understood to be a form of energy and that energy too was conserved, just like mass. Just after the turn of the century, it was found that mass was actually a form of energy and that mass could be converted into energy and vice-versa. So you could no longer say that matter was conserved but only that total energy was conserved, total energy that included the energy associated with mass. Then finally in about 1920, scientists realized that matter and energy were really just different names for the same thing, so it could again be stated that matter, which now meant the same as energy, was conserved.

2. Everything Is Matter

Science had long concerned itself only with the material world, so it is not very profound to point out that it was science's view that there was nothing in the universe but matter and the forces that affected the matter. However, during the period we are considering, the way of looking at the forces between objects changed to say that forces arise through the exchange of particles of energy and matter. So it did indeed become important to say that everything is matter — atoms, charges, and even the fields that create the forces on them.

3. The Universe Is Infinite and Eternal

The last main idea underpinning the scientific view of cosmology at the time of Joseph Smith is one not as well appreciated today. It grew out of Newton's theory of gravity, combined with actual astronomical observations. First, Newton had proved that all massive objects attract each other with a gravitational force, so any two things will pull on each other, no matter where they are in the universe. Second, observations showed that the universe is static. This creates an interesting problem. Figure 4 shows a block of the universe, uniformly filled with stars (the yellow dots in the figure). If we take a little piece and examine it closely, we see one star that is sitting in the gravitational field of all the other stars in the universe.

The red arrows in the blow-up represent the gravitational forces on the star due to the neighboring stars. If the universe is to be static, as observations seemed to say it was, then all those forces have to balance exactly. The only way you can do that is if the universe is infinite in all directions and perfectly homogenous. The Newtonian universe has to be infinite. And since the observed universe is static, it must also be eternal. No one discovered until the late 1800s that this universe is

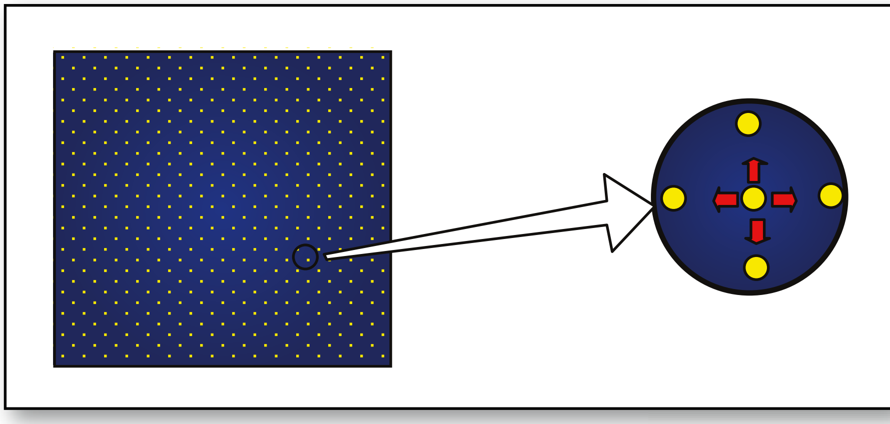

Figure 4. *A small section of an infinite universe filled with stars (at left). If we blow up a section, we see the gravity balance required for a static universe.*

unstable, and in fact, if you move anything a little bit, the whole thing collapses. But the laws of nature did seem to require a universe that was infinite and eternal.

So you see where this leaves us. From 1840 to 1930, the scientific cosmological view of the universe evolved to look like what is summarized in Figure 5. You may have seen something like this before. (Hint: Go back and look at Figure 3.)

SCIENTIFIC COSMOLOGY, 1840-1930

- "MATTER" IS CONSERVED
- EVERYTHING IS MATTER
- THE UNIVERSE IS INFINITE AND ETERNAL

Figure 5. *Elements of Scientific Cosmology, 1840-1930*

For 90 years, the LDS Church looked pretty good in contrast to the poor Catholics and Protestants who were stuck with the medieval doctrine of creation *ex nihilo*. The Mormons, for a change, had scientific opinion on their side.

The Expanding Universe

But something happened in 1930 to change all that. The change occurred as Edwin Hubble combined his own measurements of distances to various galaxies with previous measurements of their speeds to produce the comparison shown in Figure 6.

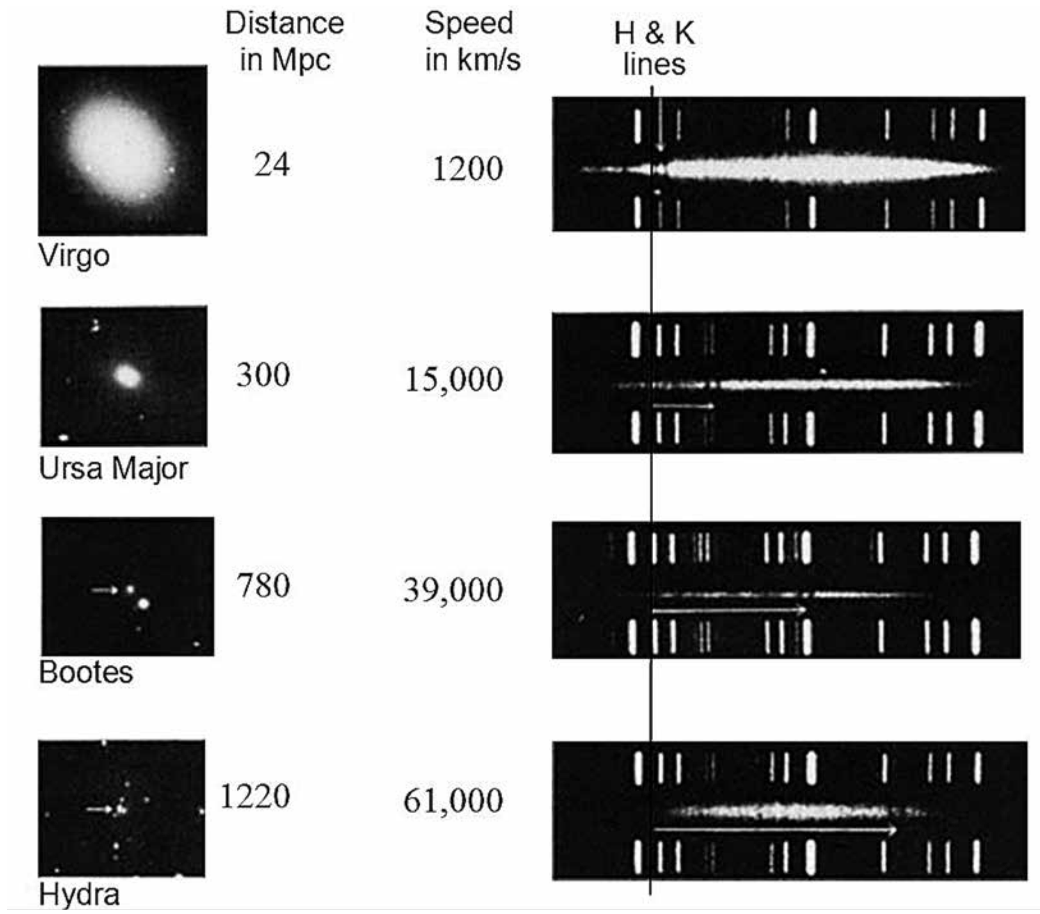

Figure 6. *The Hubble Relation*. Galactic redshifts demonstrating that the velocity of a galaxy is proportional to its distance.

The photograph in the upper-left of Figure 6 is a picture of a galaxy in the constellation Virgo. To its right we see what the light from that galaxy looks like when it is spread out in a spectrum. Violet is on the left of the spectrum and blue is on the right (this is just one piece of the spectrum). At the point labeled with the little down-arrow, we see two absorption lines. These are the H and K lines of ionized calcium, and they are almost where they would be if the calcium ions were in the laboratory, but they are a little shifted to the right. By looking at the brightness of the galaxy we can tell the distance to it (it turns out that it's twenty-four megaparsecs away). By looking at this Doppler shift in wavelength toward the red end of the spectrum (longer wavelengths), we can determine the velocity of that galaxy relative to us. It's moving away from us, and the velocity is 1,200 kilometers per second. Now we do that with a galaxy further away in *Ursa Major*. You'll notice those same two lines are there, and they're now moved further toward longer wavelength. The distance is greater, and the red shift is greater. We can do the same thing with a galaxy further away, in Bootes. And finally there's a little galaxy you can barely see, there in Hydra. Those two absorption lines are almost off the spectrum to the right, giving a speed measurement of 61,000 kilometers/second.

If we were to graph all of the galaxy distances and speeds, we would find there is a fairly strict proportionality. The further away a galaxy is, the faster it's going. The relation is linear, as shown in Figure 7.

Now think about what this means. Suppose you are standing on a freeway bridge. Here is the freeway in Figure 8, there is the bridge, and that's you wearing a large straw hat.

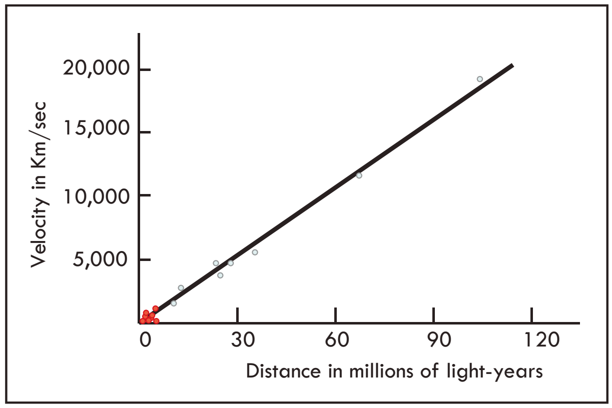

Figure 7. *A Plot of the Hubble Relation*. The red dots represent the galaxies used by Hubble to calibrate the relationship. The other empty dots are extensions to higher redshift.

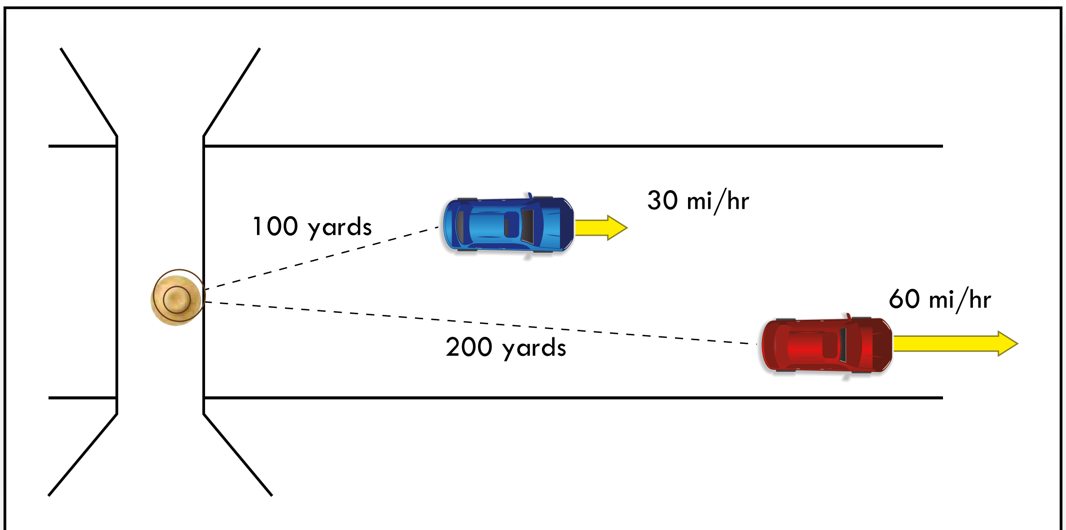

Figure 8. *The Speed Is Proportional to the Distance Away*

You're looking down from the freeway bridge, and you see two cars, one of them a hundred yards away in the left-hand lane going thirty miles/hour (this must be a freeway in Salt Lake City). And then there's another car that's twice as far away, going twice as fast, sixty miles/hour. Now, there's something really important about this linear relationship if you think about it. The one twice as far away is going twice as fast. You can see what this tells us about those two cars by running time backward. The car twice as far away backs up at twice the speed, and this means that they both arrive back under the bridge at the same time. So, as I look at these two cars that are now going away from me, I know that there was a time when both those cars were under the bridge together. Similarly, as I look out at a universe filled with stuff that's moving away from me at a speed proportional to its distance, I know that if I back up time, there was a time when all of that stuff was together, right here in this room. That is the basis for the idea of the big bang.

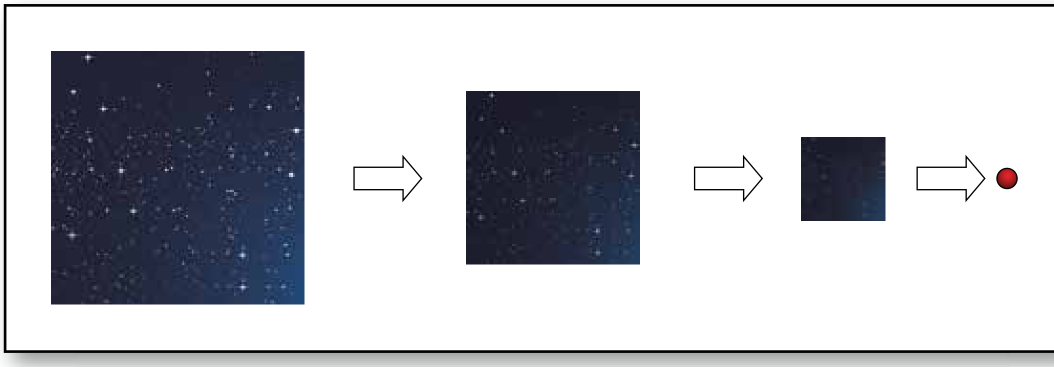

Figure 9. *As we back up time, a block of space and matter in the present universe gets smaller and smaller until it shrinks to a point, the initial big bang point.*

The Big Bang

If we take a little cubic chunk of the universe with matter and stuff in it, we can say that it has this size at the present time (Figure 9). Then, backing up the expansion, we see that the matter in this chunk must have had a smaller volume a little while back. Then it was smaller still before that, and as we go back in time, this little piece is shrinking and shrinking. Finally, the cube shrinks to a single point. Everything in this piece of the universe began at one point in time and at one point in space, and it was right here in this room.

But this still leaves one important question. Where did this one little red point come from? Most Catholics and Protestants were delighted with this question, because they had a beloved idea just waiting for a problem like this. Their idea is that God, who exists outside of space and time, created this little fireball out of nothing. Before I go on with my story, I would like to take a short aside on this subject.

An Aside on Creatio Ex Nihilo

I know we like to preach and defend our own doctrine and not criticize others' beliefs, but I can't help it: I've got to tell you a few problems I see with this, a few things that have just driven me crazy that no one else seems to worry about. Try this: "God, who lacks nothing, needs nothing, desires nothing he does not already have, nevertheless creates a universe and people who live in it." Why would he do that? Or what's worse: "God loves good and hates suffering, yet the result of his action is that most of his creations will suffer forever, eternally shut out from his presence." Why would he do that? That seems mean, and God should not be mean. And finally — and I don't know if this one bothers you, but it really bothers me — "And he makes it all so big." Why would he *do* that? Well, I've never heard a good answer to any of those questions. But let's get back to the story.

The Origin of the Universe

So, where were we? Right, we were looking at the little red dot in Figure 9. Where did this single point come from? It's a valid question, and it ought to have an answer. Scientists who are atheists cannot just attribute the big bang to God. So what is their explanation? Well, here it is, written out for you in Figure 10.

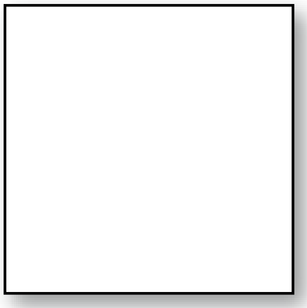

Figure 10. *The Best Explanation of Big Bang Origins*

Right. Blank. There is no answer. They … well, they're not quite sure … but maybe it came from, uh, a quantum fluctuation in, well … in *something.* I don't really mean to make fun of anyone because this is actually a very hard question, and the serious answer is that no one has a good solution. Everyone agrees it is a valid question, and scientists are concerned about it, but no one has a compelling answer. But there is one thing on which everyone agrees, Catholic, Protestant, and atheist: Joseph Smith was wrong.

Let me give you an example. Several years ago, a book came out called *The New Mormon Challenge*. It contained a chapter by Paul Copan and William Craig titled "Craftsman or Creator: An examination of the Mormon Doctrine of Creation and a defence of *Creatio ex nihilo.*" Copan and Craig addressed Joseph Smith's cosmology roughly as we have just presented it and then compared it with modern cosmology. They found a conflict. The authors express it this way:[8]

> The Big Bang represents the origin of all matter and energy, even of physical space and time themselves, as we have seen. Therefore, it is irreconcilable with the theory to hold that matter/energy are eternal or that God is the physical product of a beginningless progression . … Thus, Big Bang cosmogony is a veritable dagger at the throat of Mormon theology.

I particularly like the "dagger at the throat" remark.

Let us summarize in Figure 11 the cosmology that Copan and Craig depended on for their conclusions. In the post-1930 big bang theory, matter would not be conserved through the big bang. If there was a big bang, then whatever pre-existed the big bang was not matter. And, if there was a big bang, the universe may still have been infinite in size, but it was certainly finite in time. It was not eternal.

So, wow. It looked like Copan and Craig are correct and that the Mormons were in trouble with science again.

However, we should explain that *The New Mormon Challenge* was published in 2002, and when it appeared, it was already twenty years out of date in at least one important way. The problem with the book, as with the views summarized in Figure 11, is that it had been known since the 1970s that there were big problems with standard big bang theory. Let's see what they were.

SCIENTIFIC COSMOLOGY: POST-1930

- MATTER IS CONSERVED, EXCEPT AT THE BIG BANG
- EVERYTHING IS MATTER, EXCEPT BEFORE THE BIG BANG
- THE UNIVERSE MAY BE INFINITE, BUT IT IS NOT ETERNAL

Figure 11. *Elements of Scientific Cosmology in the Period Post-1930*

Cosmic Evolution

Let's begin by looking more deeply at cosmic evolution. The evolution of the scale of the universe is governed by Einstein's equations of General Relativity. These equations determine the distances that will be measured between galaxies that are at rest relative to the space around them. The solution that fits our present universe describes a universe that is filled with matter, and it tells us that all of the space in the universe begins by expanding rapidly and then slowly decreasing its expansion rate due to its self-gravity. If we begin at a single point, the solution for the block of matter we live in is consistent with the sequence of pictures shown in Figure 12. It begins at the single red point in the picture, expands swiftly at first, and then more slowly as time goes by. The dashed lines show the relative scale size of this block of the universe.

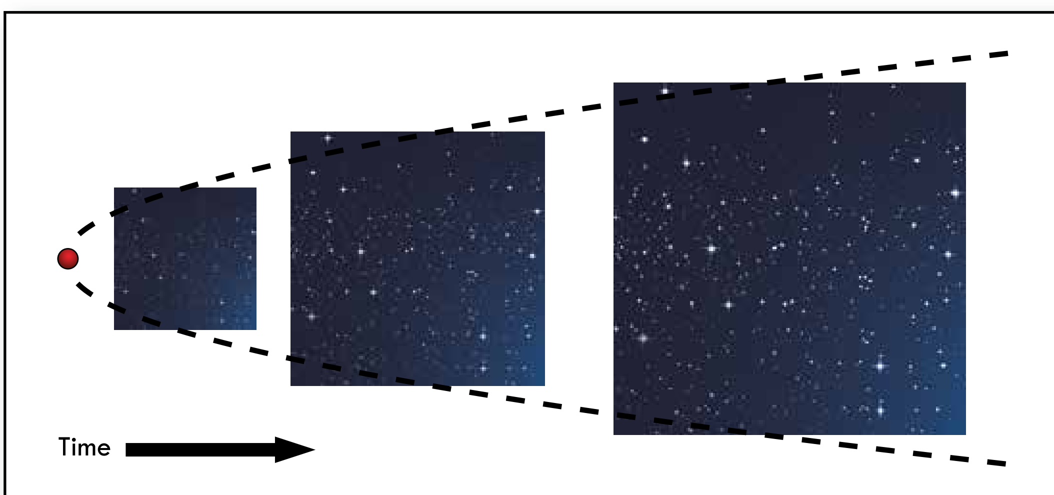

Figure 12. *The visible universe begins at a single point and expands, rapidly at first then slowing its expansion due to its own self-gravity.*

The Horizon Problem

But as I mentioned, there are three or four big problems with this picture. One of these is actually fairly simple to understand, so let us concentrate on it. It alone is enough to demonstrate that the simple big bang theory depicted in Figure 12 predicts a situation that is not observed in nature, thereby disproving the theory. The problem is referred to as the "horizon problem."

To see how it arises, let me take you through Figure 12's expansion scenario again. This time, we want to consider the orange and blue dots in picture A of Figure 13. These represent pieces of the initial big bang that will fly apart to different places in this block of the universe. Let's say that each one will eventually form a galaxy, and let's say that the expansion is so fast that the distance between these two galaxies increases at twice the speed of light. By the way, you may have heard that nothing can go faster than the speed of light, but this does not apply to the cosmological expansion we're talking about here. Trust me on this. Everyone knows it's right.

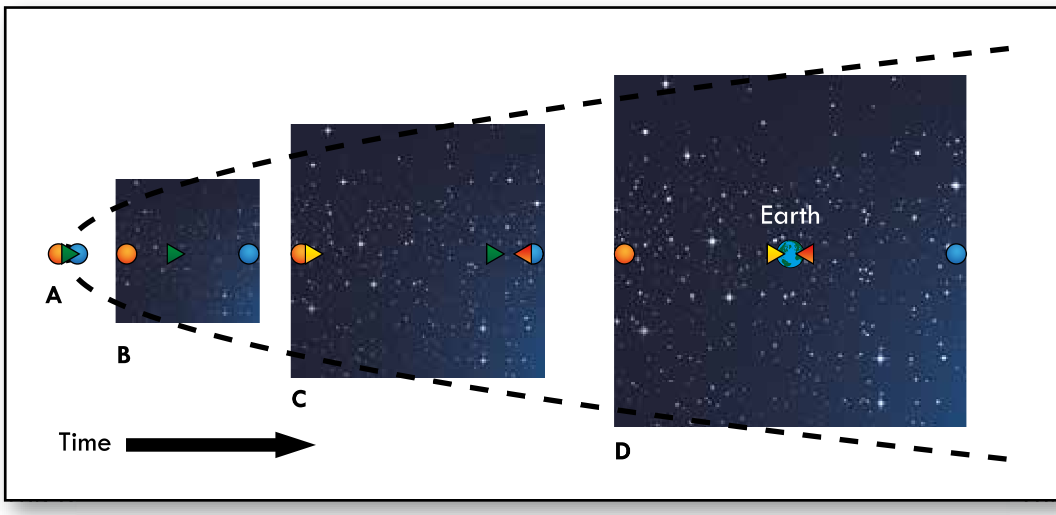

Figure 13. *Picture A is the big bang. In picture B, a photon is moving from left to right. In picture C, when the green photon has not yet reached the blue galaxy, a red photon is sent from the blue galaxy toward the left. Also shown is a yellow photon that is simultaneously sent from the orange galaxy toward the right. In picture D, both photons arrive at the earth and we see the light from the two galaxies.*

information carried by this red photon is a picture of what the blue galaxy was like at the instant the photon left. And let us be clear that this is a time before the green communication photon from the orange galaxy can have arrived at the blue galaxy. At the same time, in picture C, the orange galaxy sends a yellow photon toward the right, carrying information of conditions in the orange galaxy at the moment the photon was sent. Finally, in picture D, both signals arrive at earth and show us both galaxies as they were at the time of picture C.

Let us think what this all means. If we are on Earth in picture D, and if we look in the two directions that are 180 degrees apart, we will see the orange galaxy and the blue galaxy as they were at a time before they could have had any communication with each other. No little green photons could have transmitted any energy from one to the other. This is what we actually see in the real world as we look into the sky in different directions from Earth. We see parts of the universe at a time when they can have had no communication, no exchange of energy, between them. And yet, no matter which direction we look in our real universe, we see that everything is at the same temperature to five decimal places. This is the basis for what's called the horizon problem. It's a big problem. The big bang is this big random chaotic event. In cannot produce a uniform temperature by itself. Unless these two pieces of the universe are able to exchange energy and come to equilibrium, they can never end up at a single temperature. And yet the temperatures we see are the same everywhere. The simple big bang theory is not supported by observation.

Inflation

The solution to this problem, and to many of the known problems of the simple big bang theory, is to postulate an effect known as inflation — inflationary cosmology. The solution to the horizon problem comes about in this way.

In inflationary cosmology, it is assumed that our local block of the universe begins by expanding very slowly, as shown in Figure 14. During this initial period, there is plenty of time for photons to be exchanged between bits of the universe. Then, after what is still a relatively short time, the universe suddenly begins to inflate, to accelerate its expansion rate by a huge amount. This has the effect of driving the pieces of the universe that were long close together out to the enormous distances where we see them now. The universe comes to thermal equilibrium during the slow expansion phase, before the inflation drives it to scales so large that the pieces would no longer be able to equilibrate over the entire block. But they don't need to. As we look in different directions in the sky, we see parts of the universe that were in communication early on, allowing them to exchange energy many times. So it is no surprise that they are now at the same temperature to five decimal places.

So What?

Here is one of my favorite questions: "So what?" Haven't we just replaced a simple big bang (Figure 15a) with a more complicated one (Figure 15b)? Isn't there still a single creation from something out of nothing when time begins?

You will be interested to find out that the answer is a definitive no.

The Inflaton Field

Here is the reason. Inflation has to have a mechanism. Typically, this mechanism is taken to be the existence of a scalar field called the "inflaton." This is a field whose potential energy is given as a function of its field strength in Figure 16. We assume that the field starts off in the false vacuum state near $\varphi = 0$. Then, as time goes on, the value of the field slowly rolls down to the true minimum of the potential energy

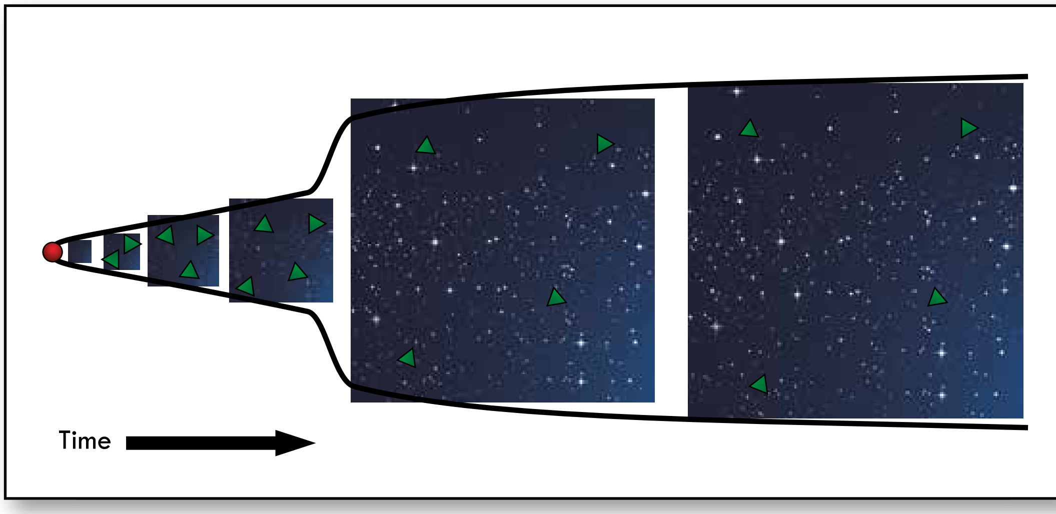

Figure 14. *An Inflationary Cosmology.* During the initial slow expansion, pieces of the local universe interact many times via the green photons. Then, once inflation starts, it separates these pieces to the huge distances we see today.

curve. During the slow roll, it produces inflation. Quantum mechanics can also allow the value of the field to fluctuate a little bit and restart the slow roll.

The point of this explanation is that some mechanism like this has to exist in an already-existing universe for inflation to have taken take place in our universe as its initial slow expansion phase ended and the inflationary epoch began. And there is no change in the laws of physics, so that mechanism must still be available in the

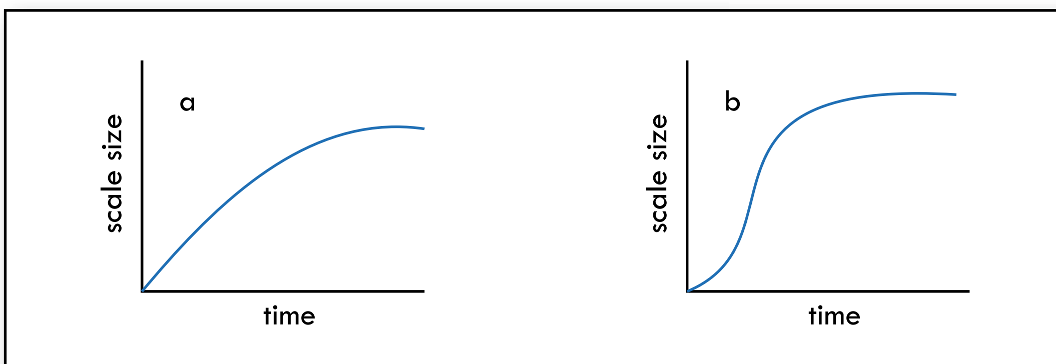

Figure 15. *Graphs of Standard Cosmology (a) and Inflationary Cosmology (b).*

universe today. Thus it should still be possible in our own universe for this inflation to take place again, starting from some small region of the present universe. Let's see what this implies.

Eternal Inflation

Figure 17 depicts the expansion by using a two-dimensional analog to our actual three-dimensional universe, so that we can see the sequence spread out in time.

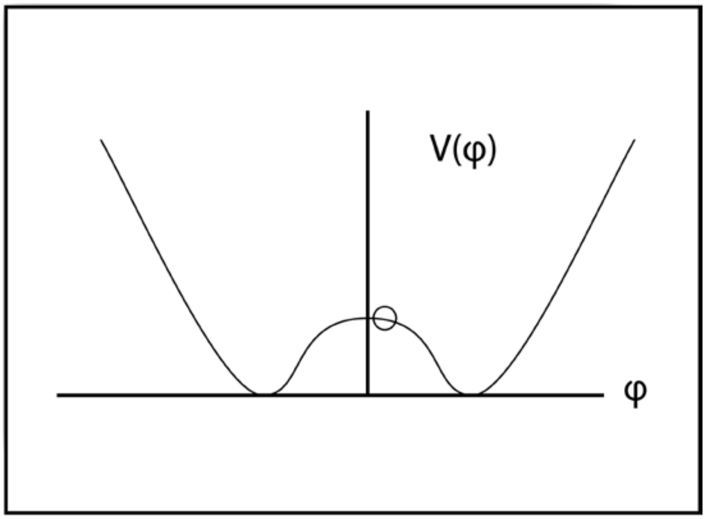

Figure 16. *The value of the inflaton field φ starts near zero in a false-vacuum with a potential energy V that is not at its absolute minimum. As the field rolls toward the true minimum, it fuels inflation.*

To see what we mean by a two-dimensional universe, consider first the blue disk at the left of Figure 17. This disk represents a section of a two-dimensional universe that stretches away in all directions in the plane of the disk. To use this picture, you pretend that there are only the two dimensions of the disk. Lines not contained in the disk are lines that leave the universe, and so they cannot exist. In this two-dimensional analog to our three-dimension universe, the spherical earth would be a small disk, the inside of the disk being the interior of the earth. We would be little two-dimensional figures who run around the outside of the disk. We can point down toward the center of the earth, or we can point up toward flat stars in the blue universe, but we may not point out of the blue surface because that direction does not exist.

The picture on the right of Figure 17 depicts the expansion of an inflating universe. The universe is represented by these little flat disks, each one a two-dimensional universe. The increase in the size of the disks from left to right represents the universe's expansion. The evolution of the scale size is shown by the outside dashed lines. It begins at the cusp at the left, representing the big bang. There is a slow expansion to begin with, then a sharp increase in scale size followed by a slow coasting and slight reduction in the rate of growth. The last blue disk on the right represents the universe we now live in, some 13.7 billion years after the beginning.

The point we want to make about inflation is shown on the last disk. Because the inflationary mechanism must still be available at each time point in the existing universe, a new inflation could begin in any one disk. In particular, it could occur now, the point represented by the last blue disk. A part of our own universe could suddenly inflate, creating new space at a rate faster than the speed of light and thereby cutting that new region off from any communication with our own universe.

If that could happen in our present universe, and the theory says that it could, then let's think again about the big bang cusp in Figure 17, the dot that represents the point from which our universe began. It could be that we are not the first space that ever inflated. In fact it's pretty likely that our universe, the result of our little

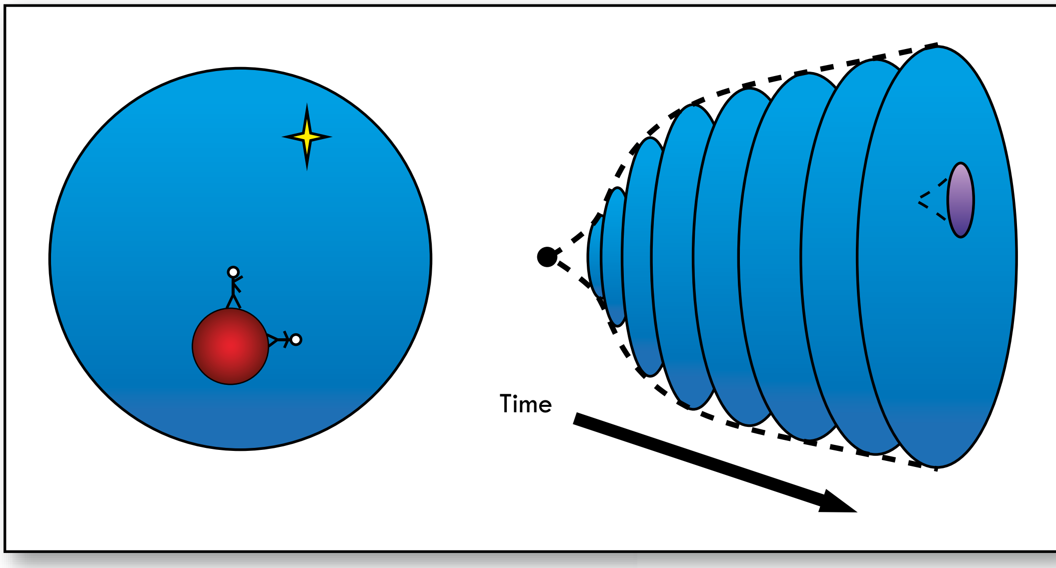

Figure 17. *The blue disk on the left represents a section of a two-dimensional universe with planets as disks and flat stars. The sequence on the right shows an inflating two-dimensional universe in which a daughter universe begins from a new inflation.*

big bang, was originally a small region in a previous universe, the orange universe in Figure 18. So our big bang was not a creation of the universe from nothing at all. It could be that it was just another inflation event in another pre-existing universe.

Now, unfortunately, the inflation pictures in Figures 17 and 18 make it look like the inflating spaces, the pink disks in Figures 17 and 18 and the blue disks in Figure 16, must either overlap the parent spaces that spawned them or must shove the parent space aside to make room for the new inflating space. That doesn't happen. To show what does happen, we're going to need another way to visualize the creation of a new inflating region of space.

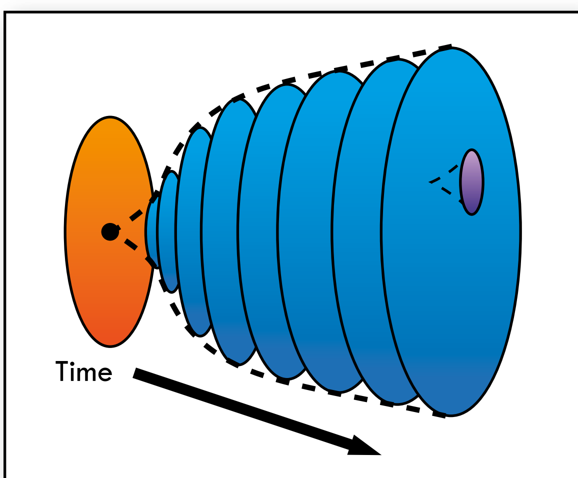

Figure 18. *Our own universe may have begun as an inflation event in a parent (orange) universe.*

We are going to look at another two-dimensional analogy to our three-dimensional universe, but this time, instead of using a flat surface like the disks in Figures 17 and 18, we are going to use the two-dimensional surface of a sphere. Even though a sphere is a three-dimensional object, the surface is still two-dimensional, since it only takes two numbers (longitude and latitude) to specify every point on the surface. The universe is the surface here, not the whole sphere, so the inside of the sphere and the space outside it are not part of the universe; they do not exist in the analogy. Figure 19 shows such a two-dimensional space, with a small disk for the earth, flat people on the earth, and a flat star shining far off in some direction.

Although we are considering a two-dimensional universe in the figure, we actually live in a three-dimensional universe, so we can use the extra dimension to picture the universe expanding like a balloon that is being blown up. Unfortunately, a sphere is a closed figure, so we can't picture this on the page. So, instead of drawing the entire surface of the sphere, I'm just going to draw the edge of this sphere. This way, we can watch it as it expands. This is shown in Figure 20.

The first three semicircles represent the radius of the sphere increasing at a uniform rate. But in the fourth circle, we see a dimple start to form. This growing [illegible]egion of the universe that suddenly becomes greater than the uniform expansion of the rest of the sphere. The growth of the bump does not interfere with the expansion of the rest of the space; it just creates a bubble on the balloon, a small bump on the otherwise uniformly expanding background surface. As the bump grows, this super-inflating piece of the surface produces its own new space, a new "bubble universe." If the size of the bubble is great enough, the speed at which new space is created can be much greater than the speed of light, thus recreating the situation we see in our own universe at the present time.

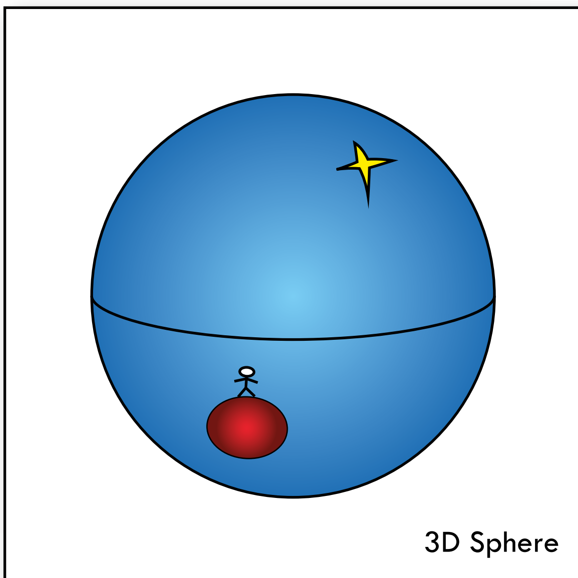

Figure 19. *A two-dimensional analog to the universe where the surface is the two-dimensional surface of a sphere.*

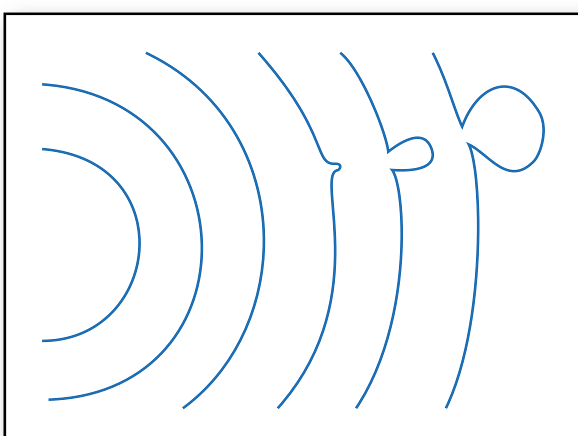

Figure 20. *The creation of a bubble universe by rapid inflation in a background, uniformly expanding universe.*

So as far as we know, our own universe may not be the one that started out in the first three semicircles of Figure 18, but it might just as well be the little bubble universe that grew from it. In his case, our universe would not have been the first universe to form. And of course, our parent universe, the one that spawned us by the sudden inflation event, need not have been the first universe ever formed, either. It might itself have arisen from an inflation event in its own parent universe.

This sequence of parent and daughter universes has no reason ever to have had a "first universe" event. Indeed, the infinite sequence allowed by such an inflationary mechanism has been given the name of "Eternal Inflation," and the infinite collection of parent and daughter universes is called the "multiverse."

Zero-Energy Universe

Now suppose that a little one-foot-diameter sphere right here in this room were to experience a sudden quantum fluctuation in the value of its inflaton field to a non-vacuum value and then begin to slow-roll back to its true vacuum state, driving this space to inflationary expansion. We have said that this could produce a new bubble universe. But since there is not much matter inside this little blob of air, how could a universe full of matter be created? Where would the matter come from?

One of the goals of cosmological observations over the last several decades has been to determine the average density of matter-energy in the universe. This is critical because the size of the universe, whether finite or infinite, is determined from Einstein's equations, with the average density as the crucial parameter. And one of the results that has become increasingly clear as time goes on is that the observed density is outrageously close to what is called the "critical density." At the critical density, the universe is just barely infinite in size. So it appears from observations that our universe is actually infinite.

But this density has another special property. At the critical density, we have a case where the positive energy of all the matter in the universe is just exactly balanced by the negative gravitational potential energy that binds the universe together gravitationally. This balance is not a coincidence but arises naturally in inflationary cosmologies. Since this balance means that the total energy content of the present universe is zero, the energy required to fill an inflating universe with matter is zero. The matter arises naturally as the result of the newly-created negative gravitational energy spawning positive mass-density energy. This outgrowth of inflation that occurs in a universe with the critical density is termed the "Zero-Energy Universe." A chapter in a recent book by Pasachoff and Filippenka expresses it like this:

> The idea of a zero-energy universe, together with inflation, suggests that all one needs is just a tiny bit of energy to get the whole thing started (that is, a tiny volume of energy in which inflation can begin). The universe then experiences inflationary expansion, but without creating net energy.[9]

The thing required for positive energy to be created in the inflation process is the principle that the initial zero total energy is conserved. The matter is not created out of nothing but rather out of the principle of conservation of energy. As we said, the modern name for this creation of matter from pure energy is "zero-energy universe," but it might be said equally well in other words that there is a pure principle of element at work. Total energy is not created or destroyed, but positive matter energy is created as the negative gravitational energy of the matter appears.

Joseph Smith and Inflationary Cosmology

So let's see where this leaves us. Figure 21 summarizes the elements of an eternal inflation universe with an exact zero-energy condition producing the critical density of matter.

Not bad for a young Mormon boy in 1840. But let me be clear. I am not suggesting that that the lack of a case for a conflict between modern cosmology and Joseph Smith's cosmic teachings is evidence at all for his prophetic calling. There are far too many assumptions on my part in this discussion and far too little agreed on among cosmologists for that to be the case. But it is clear to me that there is absolutely no good case against Joseph Smith from modern cosmology. There are reasonable ways to harmonize the two sets of doctrine, and naive big bang challenges to the doctrines of the Restoration are out of date.

INFLATIONARY COSMOLOGY

- THE PRINCIPLES OF MATTER ARE CONSERVED
- EVERYTHING IS MATTER
- THE MULTIVERSE IS INFINITE AND CAN BE ETERNAL

Figure 21. *Elements of Inflationary Cosmology*

Full Disclosure

However, full disclosure requires me to tell you that there are three little problems with this picture that I've given you, interpreting Joseph Smith's cosmology in light of our modern understanding of inflationary cosmology. All three of the problems revolve around the same basic conflict between physics and LDS theology.

The first of these is a technical challenge to the idea of eternal inflation itself. In 1994, Bordé and Vilenkin[9] claimed to have proven that the multiverse has to have a beginning. They showed that timelike worldlines, paths through space and time for particles that travel slower than the speed of light, cannot have infinite length into the past. There must have been a beginning. So Joseph Smith looks like he may still be in trouble here. It is important to note, however, that many cosmologists do not agree with the conclusion of the Bordé-Vilenkin proof. The proof makes many assumptions. It is not clear that the proof works in a zero-energy universe or that the finite-length calculation Bordé and Vilenkin do actually addresses the question of whether or not there is a beginning to the universe.

There is another sort of related problem, anyway, if we want to put God into this picture. It is this: Since most of this little bubble universe is expanding faster than light, how does God get into his new universe, and how can he travel around inside of it, because nothing can travel faster than light?

And finally (actually, this sort of bothered me when I was younger), since nothing — no signal, no information — can ever travel faster than light, how does God answer my prayers?

All of these problems arise if there is an absolute speed limit — the speed of light — on all signals and travel. The speed limit strengthens the Bordé-Vikenkin proof; it limits God's ability to visit all of his universe, and it violates my own experience that God answers my prayers immediately. Well, contrary to popular opinion, even among physicists, things can travel faster than light.

The explanation for this is a little more technical than what we have been discussing until now, so I have decided to put it into an appendix at the end of the paper. You can either trust me on this, or you can go and follow the argument yourself.

Summing Up

Let me end by reiterating my two main takeaway points.

First, don't forget your quiz question. Remember that we may expect apparent conflicts to arise between science and our LDS religion because scientists can misinterpret what they see, and Mormons can misinterpret what they read.

The second point is the one from my story about the Dark Energy Task Force. It is that this is no time for anyone to criticize anyone else's beliefs based on what *cosmologists* know.

Questions

Q: “Why should we believe that dark matter exists when there is no evidence? And is it not more likely that our understanding of gravity is incomplete?”

A: There is plenty of evidence for dark matter, or no one would believe in it. However, it is certainly possible that the problem lies in our understanding of gravity. A lot of very smart people are looking at possible alternatives to the theory of gravity as an explanation for the apparent effects of dark matter on the dynamics of the galaxies and of the universe. But remember that whatever theory you suggest as an alternative has to be “complete.” That is, it has to exactly reproduce all the things that we know gravity predicts correctly and then has to give us something else to solve the dynamics question.

Let me elaborate a little. The presence of dark matter is obvious from cosmological observations. As the universe expands on the largest scales, the medium-scale contraction of clusters of matter and the size and evolution of the resulting structure as seen in the observations of the early universe leads us to say that there must be a component of matter that we cannot see. It has to have about four or five times greater density than the matter we can see. No one knows for sure what form or forms it would take. A lot of searches have been made, looking for various possibilities that have been suggested, but none of them have been successful at finding evidence for that particular form. But the evidence from the expansion and the clustering is clear, and so everyone agrees that it has to be there.

Q: “Would theories and understanding of quantum mechanics advance if scientists realized that energy is alive and applied principles of biology to the studies?”

A: I don’t know. I’d have to understand what that question is really about. So, if you want, come grab me, and I’ll try to respond to the question.

Q: “Is it possible that the big bang occurred from the death of a previous universe?”

A: There is a cosmological model that says there was a big crunch in a previous universe that brought everything back together, and then there was a rebound. I know the guy who first invented this theory. It’s viable but not compelling. The question was “Is it possible?” The answer is yes.

Q: “The universe is filled with galaxies. What is outside the universe?”

A: There is no outside the universe. If the universe is infinite, then there are galaxies as far as you can go in any direction. If the universe turned out to be finite (and I really don’t want to go into that), then as far as you can go out in any direction there are galaxies. The only difference is that if you go far enough in a finite universe, you end up back here at this podium. There is no outside. In any direction I can point I can tell you everything that’s there, finite or infinite, curved or not.

Q: "Could the black hole have something to do with the bubble caused by universe inflation. That the black hole is where the birth of the universe came from?"

A: A black hole is a solution of the Einstein equations. There are a number of ways that you can think of it physically, ways that the geometry of a black hole might come about. In a sense, you could argue that the singularity at the beginning of the universe is associated with a black hole. But it doesn't fulfill a lot of the geometrical requirements of black holes. I guess I can't give a very good answer to that. My best answer is "I don't think so."

Q: "Why does the universe seem to be expanding in every direction from us? Do we just happen to be at the center or does it have something to do with the fact that we are doing the looking?"

A: If I had more than five minutes, I actually have a nifty little slide here that answers that question. But let me summarize: let's assume I'm on one side of the universe and I see the universe out there. Something a long ways away is moving fast, something that's close to me is moving slower, and everything is proportional. I would see that everything is moving away from me. But if I went over and stood on one of those galaxies, I would see this room moving away from that galaxy. If you look at the details, every galaxy would be moving directly away from me when I am over there as well as it does when I'm here. So this case of proportional expansion means that every point in the universe is expanding away from every other point.

Q: "What about the possible unreliable accounts of Joseph Smith's discussions about moonmen and sun-men?"

A: I don't know. But, if Joseph Smith actually said this, he probably learned it from the great British Astronomer, William Herschel, not from God. Herschel taught, long before the days of Joseph Smith, that the moon was definitely inhabited and that the sun probably was as well.

Q: "Do you see any correspondence between information theory increasing entropy and the Mormon idea of intelligence?"

A: I'm afraid I can't think that one over in five minutes well enough to be able to answer it. I don't see anything offhand, but I'd like to talk to whoever asked that question. It is an interesting question.

Q: "Quantum theory states that a positive-negative particle pair — a matter, anti-matter pair — can pop into existence out of the vacuum and then disappear again unless the pair appears near the event horizon of a black hole. Doesn't this contradict the idea that matter is eternal?"

A: The energy that appears in virtual pair creation does not last for long. It must disappear again as the particles annihilate. But, if one of the particles goes into a black hole, the other remains, but at the expense of the energy of the black hole. So total energy is still conserved. This idea, by the way, is the basis for Steve Hawking's theory of black hole evaporation. It's a very well-respected theory and seems sound, but it is working in an area where the fundamental physics is very difficult to apply. And searches for evaporating black holes in the universe have so far been negative.

Q: "If everything is matter, what of the idea of perfect justice or perfect triangles or mathematic equations? These are clearly not material, what are they?"

A: They don't exist. These are concepts in the minds of men. If men quit thinking about them, the concepts go away.

Q: "What about string theory?"

A: I had one slide that you should be glad I didn't show you. One of the other theories that I love is that instead of using inflation to solve the horizon and other big bang problems, Turok and Steinhardt had an idea they call the Ekpyrotic Universe. In this theory, the universe is really a ten-dimensional space. Six of the dimensions are curled up in a tight six-dimensional ball, and their only effect is to give us the Yang-Mills fields and the coupling constants. The other four dimensions are divided into a space of three dimensions (a three-dimensional membrane which is the universe we live in) and a fourth spatial dimension. In addition to our three-dimensional membrane, there are other membranes that exist side-by-side in the fourth dimension, and a universe is created when one of those membranes slams into the other and suddenly fills it with matter and energy. After this, it has all the earmarks of what we see in the universe today. This is a reasonable theory. And, by the way, the universe it predicts is eternal, it's infinite, and energy is conserved in it.

Q: "What's your opinion on the plasma hypothesis of the origin of the universe?"

A: I think my time's up. No, I'd like to talk later to whoever asked that question. I know a little about the theory. It has some serious problems, the primary one being its lack of numerical predictions for most of the effects it is trying to explain. In physics, a viable theory has to be complete enough to completely explain the effects it wants to explain. This theory is not yet viable.

Appendix: Hyperlight Travel in Two-Tensor Theories

The idea that things can travel faster than light is not generally known even by physicists, but the case is easily made and easily understood. Once it is understood how we are approaching the question, it is obvious to almost all physicists that this hyperlight speed is entirely possible.

Let us first consider the structure of space and time in normal physics. We begin by specifying a coordinate system centered on some object as origin and then locate the cosmic distribution of matter in this coordinate system. Based on the observed distribution of the cosmic matter, Einstein's field equations then determine the values of the sixteen elements of what is called the "metric tensor" *g*. These sixteen elements are shown in Figure 22. They determine the distances and times that will be measured between events whose coordinates we know.

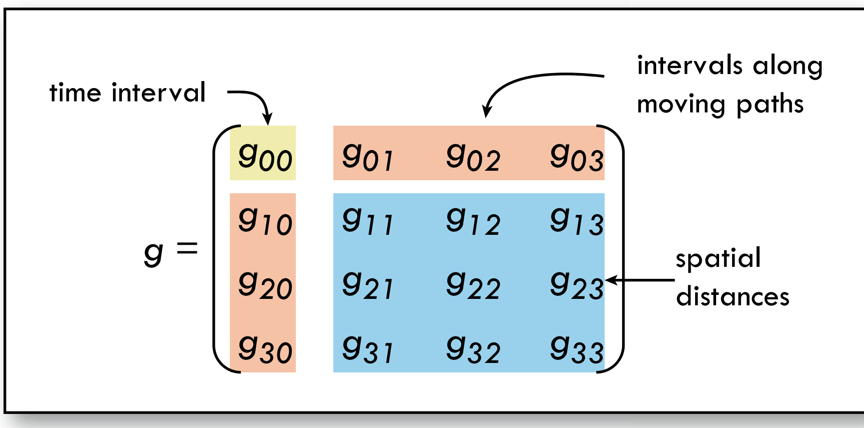

Figure 22. *The elements of the metric tensor and what they measure.*

Thus, beginning with space-time coordinates for any two events, I can use the metric tensor to determine distances and times between them. This single yellow element in Figure 22 gives the time interval between two events. This little blue block tells me how to calculate spatial differences between points that are at rest, and these two little salmon-colored blocks tell me how to calculate space and time intervals along moving paths. Now, it is the nature of the way we define a coordinate system that I can always find one system that's moving at the correct speed to make the metric tensor end up looking like this:

$$g = \begin{pmatrix} g_{00} & 0 & 0 & 0 \\ 0 & g_{11} & g_{12} & g_{13} \\ 0 & g_{21} & g_{22} & g_{23} \\ 0 & g_{31} & g_{32} & g_{33} \end{pmatrix}$$

This is the simplest I can get things by choosing a frame of reference, but I am also free to orient and scale my space and time axes as I like. It turns out that I can always adjust them so that the metric looks like what is called the Minkowski tensor:

$$g = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

If my units of time are seconds, then the one (1) in the time spot of the metric and the fact that I have minus ones (–1) down here for the remaining elements says that I must be measuring distance in light seconds. Actually, this tensor is unique in that it does not change if I transform it to a new coordinate system moving at constant velocity relative to the original coordinate system.

I now want to create a space-time diagram that illustrates the relationships between events in the reference frame I have chosen. Because I want to be able to visualize this, I will only include two dimensions in space, along with the one time dimension. The space-time diagram for the Minkowski metric is shown in Figure 23. I have an *x* and a *y* axis in space, and this vertical axis is the time axis.

Let's look at the signal that starts here at t = 0, at the origin of the axes, and moves away from the origin along the magenta path in Figure 23. As you can see, it covers one light-second of space in one second of time. One light-second per second — that would be a beam of light. So this little magenta world line represents one light signal of all possible light signals that can leave the origin in different directions. All of

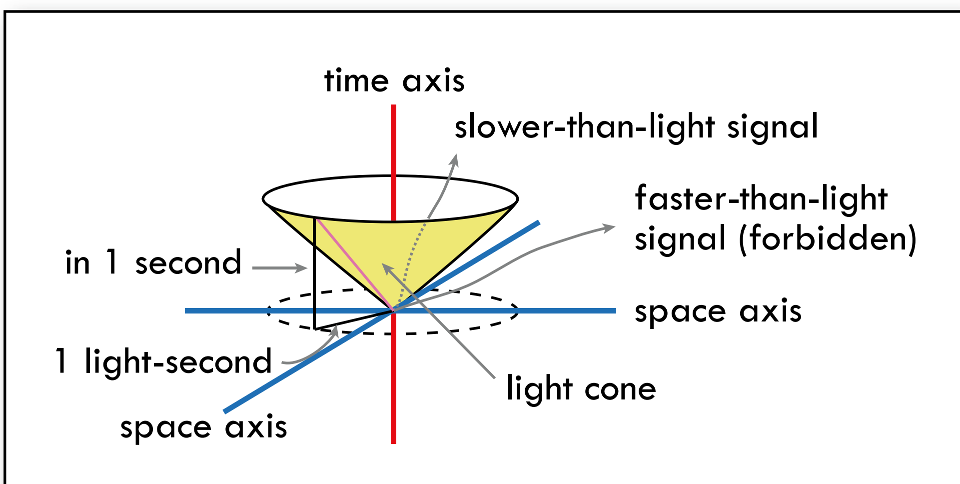

Figure 23. *A space-time diagram with blue space axes and a red time axis. Light signals from the origin will lie in the yellow light cone. Two black world lines are also depicted.*

these signals that start from the origin must lie on the yellow light cone. Anything moving slower than light will have a world line that stays inside the light cone, and any world line outside the light cone represents something moving faster than light.

The laws that govern all the normal matter and fields we know have the *g* metric as part of their mathematical expressions. We say that normal matter "couples" to this metric tensor. These theories are experimentally verified, and it is part of these verified theories that no physical particle can have a world line faster than light. All real world lines must lie inside the light cone of Figure 23.

The Spirit Sector

Joseph Smith told us that spirit is matter, but he also qualified that by saying it is also different. "More fine and pure," he said. Joseph did not say that spirit matter coupled to a different metric, but he could not possibly have used those words in 1840 or even worried about a possible speed limit for spirit matter. So it is up to us to consider the possibility that there exists a second tensor in nature, one that likewise couples to the large-scale structure of the universe, but couples instead to the spirit sector of the universe — a metric tensor whose elements are determined by the distribution of spirit in the universe. Since we are supposing that this second metric tensor couples not to matter, but to spirit, then a framework arises in which the speed of spirit matter might not be not limited by the speed of light, as we shall see.

Let us call this spirit metric the tensor *h,* defined to have components like this:

$$h = \begin{pmatrix} h_{00} & h_{01} & h_{02} & h_{03} \\ h_{10} & h_{11} & h_{12} & h_{13} \\ h_{20} & h_{21} & h_{22} & h_{23} \\ h_{30} & h_{31} & h_{32} & h_{33} \end{pmatrix}$$

Now I can always find a coordinate system moving at one particular velocity that will simplify the spirit metric without changing the Minkowski metric (which, you remember, does not change if I transform to another frame moving at constant velocity relative to the first). The new metric can thus be made to look like this:

$$h = \begin{pmatrix} h_{00} & 0 & 0 & 0 \\ 0 & h_{11} & h_{12} & h_{13} \\ 0 & h_{21} & h_{22} & h_{23} \\ 0 & h_{31} & h_{32} & h_{33} \end{pmatrix}$$

That's the best I can do with the freedom to change coordinates. But if it also happens that the spirit matter is distributed uniformly relative to normal matter, then by symmetry arguments, I know that the spirit tensor will take this form:

$$h = \begin{pmatrix} a^2 & 0 & 0 & 0 \\ 0 & -b^2 & 0 & 0 \\ 0 & 0 & -b^2 & 0 \\ 0 & 0 & 0 & -b^2 \end{pmatrix}$$

where a and b are determined by some kind of spiritual field equations and by the spirit density in the universe. In the case where a is greater than b — and that would be determined by equations that I don't know — then the counterparts of the light cones would be spirit cones with a speed that is greater than the speed of light. And so we would have a situation like Figure 24, in which spirit signals will travel along the wider blue spirit cone. All normal matter has to stay inside the light cone, but spirit, because it couples to a different metric tensor, could travel much faster than light.

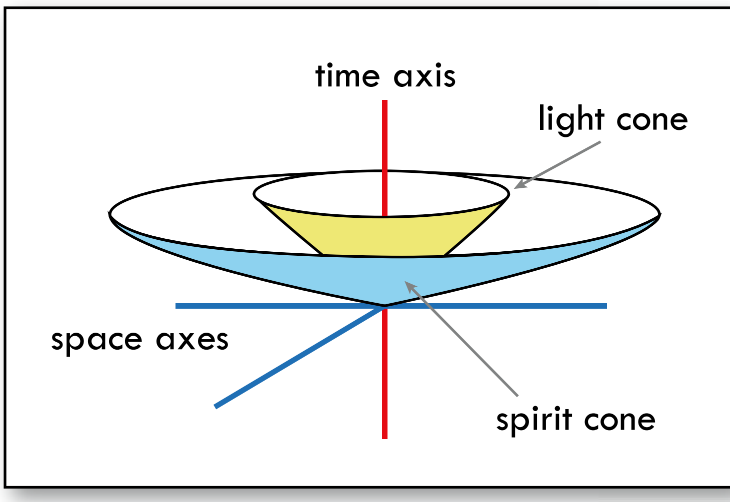

Figure 24. *The matter light cones (yellow) and the spirit light cones (blue) in the case where a>b in the spirit metric. Matter must follow world lines inside the yellow cone, but spirit can have world lines outside the yellow light cone.*

So spirit communication has no speed limit. But you knew that, didn't you?

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Endnotes

1. Quoted in P. Davies and J. Brown, *Superstrings*, pp. 3-4. There is no known source for this quotation, so some have challenged its authenticity. This attitude, however, seems to underlie Kelvin's famous 1900 address to the British Society for the Advancement of Science. And similar thoughts were expressed by other well-known physicists of his time. In 1894, American Physicist Albert A. Michelson's judgment of the situation was, "it seems probable that most of the grand underlying principles have been firmly established." Michelson went on to add, in a likely reference to Lord Kelvin, "An eminent physicist remarked that the future truths of physical science are to be looked for in the sixth place of decimals." (Cited in J. Horgan, *End of Science*, p. 19.)

2. J. F. Smith, Jr., *Answers* 2, p. 191. "Following the Apollo moon landings and the death of President David O. McKay, President Smith became president of the Church. At a press conference following his assumption of Church leadership, he was asked by a reporter about this statement. President Smith replied: 'Well, I was wrong, wasn't I?'" (Personal reminiscence of David Farnsworth provided to FairMormon [21 November 2010]).

3. J. Smith, Jr., *Teachings*, 25 March 1839, p. 137.

4. Ibid, p. 158.

5. Ibid., 7 April 1844, pp. 351-352. Cf. J. Smith, Jr., *Words*, 7 April 1844, pp. 341, 345, 351, 359, 361.

6. J. Smith, Jr., *Teachings*, 16 June 1844, p. 373.

7. Ibid., p. 353.

8. P. Copan and W. L. Craig, "Craftsman or Creator," p. 147.

8. J Pasachoff and A. Filippenko, *The Cosmos*, p. 532.

9. A. Bordé and A. Vilenkin, Eternal Inflation.

RON HELLINGS

Ron Hellings was born and raised in Pasadena, California. After serving two and a half years in the French East and Franco-Belgian missions, he returned to marry his sweetheart, Dee, and complete a BS in Physics at BYU, an MS at UCLA, and a PhD at Montana State University-Bozeman.

Ron has taught Physics at Southern Oregon University, University of Nevada-Las Vegas, Cal Poly-Pomona, Harvey Mudd College, and Pomona College. He spent twenty-five years as a Research Scientist at NASA's Jet Propulsion Laboratory before moving back to Bozeman in 2001 to work as a Research Professor in the Physics Department. For a period of three years during his time at Montana State University, he was on loan to NASA Headquarters in Washington, DC, to act as Program Scientist for the Astrophysics Theory Program.

Ron's research interests are alternative theories of gravity, experimental relativity, solar system dynamics, gravitational wave astronomy, pulsar timing, and relativistic cosmology.

Ron is basically a Gospel Doctrine teacher, having spent most of his adult life in that calling in various wards. He recently served as bishop of the Bozeman University Ward and is currently a member of the High Council in his stake. Ron and Dee have three children and four grandchildren.

Ron has written a testimony on MormonScholarsTestify.org. There he points out that he is a skeptic. He says that he does not recommend that attitude to anyone, but that he cannot help it for himself. He simply cannot believe anything without a good reason. He goes on to explain that even his faith in God is based on only the strongest of evidence. It is based on the fact that he has spoken to God and that God has answered. He knows that this happened, he says, because he was there. And he explains that, for him, all other evidence from any other source must be explained reasonably and in light of the undeniable evidence of those experiences.