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THE BIG BANG: WHAT DOES IT MEAN FOR US?

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To say that everything came from the Big Bang is like saying babies come from maternity wards—true in a narrow sense, but it hardly goes back far enough. Where did the stuff that went “bang” come from? What was it? Why did it bang?¹

Alan H. Guth, codeveloper of the concept
of the inflationary universe

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1. Brad Lemley, “Guth’s Grand Guess,” *Discover*, April 2002, 32.

Review of Paul Copan and William Lane Craig. “Craftsman or Creator? An Examination of the Mormon Doctrine of Creation and a Defense of *Creatio ex nihilo*.” In *The New Mormon Challenge: Responding to the Latest Defenses of a Fast-Growing Movement*, ed. Francis J. Beckwith, Carl Mosser, and Paul Owen, 95–152. Grand Rapids, MI: Zondervan, 2002. 535 pp., with glossary and indexes. \$21.99.

Introduction

Our imaginations are stretched to try to understand our remarkable universe and its origin. Why do astronomers say the universe is expanding? Did the universe start with a big bang? What was the universe made from? What is outside the universe? How does the big bang impact Latter-day Saint doctrine? In this essay I describe the observations (facts) that led to the concept of a big bang and discuss some of the ideas, theories, and scenarios it has spawned. Armed with that knowledge, I rebut the arguments of a recent article that attempts to use the big bang to discredit Latter-day Saint theology and discuss some aspects of the intersection of Latter-day Saint theology and current knowledge of the universe.

What is the big bang?

In the 1920s, Edwin Hubble used the 100-inch telescope at the Mount Wilson Observatory to explore the so-called spiral nebulae, many of which turned out to be galaxies outside our own Milky Way Galaxy. Hubble built upon a discovery by Vesto M. Slipher that light from distant galaxies is shifted slightly toward longer wavelengths (a phenomenon called a red shift), indicating (because of the Doppler effect) that these galaxies are moving away from us. Examinations of many galaxies showed that their speeds (away from us) were proportional to their distances, and this demonstrates that an observer in every galaxy would see the same expansion. (The rule is now labeled Hubble's law.) On the basis of this observed principle, astronomers conclude that the universe is expanding.

Imagine, now, a film of the expansion run in reverse. On such an imaginary journey backward in time, an observer would see the galaxies move closer and closer together. Eventually, all galaxies and their contents would have been squashed into a high-density soup of matter and radiation and ultimately, it would seem, into a point of infinite density called a singularity, which is a space-time point at which mass-energy density becomes so high that space-time is curved in upon itself, the usual descriptions of matter and energy break down,

and physical quantities become infinite, meaning "unbounded." (There is no information beyond that point.) At some long-ago epoch, this tiny speck started to expand, and scientists have adopted Sir Fred Hoyle's scornful nickname—"big bang"—for that expansion. (Following others, I write big bang without capitals.) The term *big bang* is used for both the whole expansion period and, by some authors, for the presumed moment of origin at time zero. Since science can tell us so little about the origin, I restrict myself to the first usage.

The general theory of relativity, announced by Albert Einstein in 1916, states that the laws of nature do not depend upon the motion or acceleration of the observer and that the properties of space are related to the mass-energy within it. It is succinctly described by theoretical physicist John A. Wheeler: "Matter tells space how to bend; space tells matter how to move."² The general theory of relativity made several predictions that have since been verified to a high degree of accuracy, and the theory is now generally accepted by scientists. When Einstein applied the general theory of relativity to the universe in 1917, his equations indicated that the universe—the space in which stars and galaxies exist—was unstable due to the influence of the combined gravitation of all the galaxies. (Prior to Hubble's discovery, the accepted view was that the universe was static.) To counteract attractive gravitation and produce a static universe, Einstein added another term to his equations, and it became known as the cosmological constant (or, more generally, the "cosmological term").

Commencing with Einstein's publication of the general theory of relativity and extending through the 1930s, physicists and mathematicians further applied equations from the general theory of relativity—without the cosmological constant—to the universe under various assumptions and found that they described an expansion. Since these theoretical results agreed with Hubble's expanding universe, Einstein naturally abandoned his cosmological term (calling it a great mistake).

2. See astro.physics.sc.edu/selfpacedunits/Unit57.html (accessed 27 September 2004). See also John A. Wheeler, *A Journey into Gravity and Spacetime* (New York: Scientific American Library, 1990), 11–14: "Matter tells spacetime how to bend and spacetime returns the complement by telling matter how to move."

However, the cosmological term didn't quite disappear from the scene, and in recent years it has again become important, as we shall see.

Present scientific theories of the big bang really deal with the *aftermath* of the big bang, and we must be cautious about earlier epochs, incredibly short though they were. As shown below, the standard hot big bang model starts a tiny fraction of a second after a conjectured time zero ($t = 0$). Inflationary scenarios (discussed later) can take us a tiny bit nearer the beginning. Perhaps M-theories (also discussed later) can take us even closer. But conditions very near the presumed time zero are still unknown. One physicist writes: "The beginning of time is, perhaps not surprisingly, one of the most speculative topics in cosmology. As we traverse this uncharted territory, keep in mind that the picture of cosmic history that we draw, and even the questions that we might ask, depend on our current (and still preliminary) understanding of physical law at these enormous energies and temperatures."³

Besides lacking a complete theory, scientists have very little observational data from the early days of the universe. The flight of the galaxies yields no data on the beginning. The cosmic microwave background (CMB) radiation provides the best and earliest information, but that radiation survives from the epoch when the universe became transparent with the formation of atoms—about three hundred thousand years after the beginning. (Before that time, the universe was too hot for atoms to form.) Very old galaxies, whose discovery is mentioned in the media from time to time, date from a few hundred million years later.

During the 1940s and 1950s, a rival to the big bang theory—the steady-state theory—was proposed by Hermann Bondi and Thomas Gold, who were later joined by Fred Hoyle. This outspoken trio suggested that as galaxies fly apart in space, new matter (in the form of hydrogen atoms) spontaneously appears from nowhere to maintain the same overall matter density. Most physicists balked at the concept of creation of matter out of nothing, but backers of the theory declared

3. Fred Adams, *Our Living Multiverse: A Book of Genesis in 0+7 Chapters* (New York: Pi, 2004), 38.

it was no more outlandish than the idea of creation of matter out of nothing through the big bang.⁴

About 1949, George Gamow, often called the brightest physicist who did not win a Nobel prize, suggested that the big bang would have been very hot near the beginning. Aided by a bit of luck, he and his collaborators predicted that the light from the initial “fireball”—originally gamma rays (more energetic than x-rays) but now red-shifted into the microwave radio spectrum—might still be observable. Since no equipment at that time could detect such radiation, the paper was almost forgotten. However, in 1965 a pervasive microwave radiation, seen in all directions of space, was detected and eventually identified as the predicted relict radiation. It is now known as the 3 K CMB radiation, because its spectrum is precisely that expected from an ideal radiator at that temperature (actually, 2.7 K). (Scientists measure temperature in absolute degrees or Kelvins, or K, and 273 must be subtracted from K to obtain temperatures in degrees Centigrade, or C.) The CMB radiation was emitted at a very high temperature (and therefore at very short wavelengths) but has been greatly red-shifted by expansion and cooling in the intervening eons to its present shape. It fills all space and forms a curtain beyond which (and therefore earlier than which) we cannot observe. All information from earlier epochs is either extrapolated or based on theory.

Is the big bang important to Latter-day Saints?

A group of evangelical scholars have mounted a broad frontal attack on certain doctrines of the Church of Jesus Christ of Latter-day Saints in a recent book, *The New Mormon Challenge*. In a chapter with the title “Craftsman or Creator? An Examination of the Mormon Doctrine of Creation and a Defense of *Creatio ex nihilo*,” Paul Copan and William Lane Craig put forward several claims regarding the big bang and its perceived relation to Latter-day Saint theology:

4. An interesting description of the life and times of the steady-state theory is given by Martin Rees, *Before the Beginning* (Reading, MA: Addison-Wesley, 1997), 36–47.

1. The standard hot big bang theory is the best description of the origin of the universe.

2. An initial physical singularity in the standard big bang theory both requires and proves *creatio ex nihilo*—the creation of the universe from absolutely nothing. “The standard Big Bang model . . . thus describes a universe that is not eternal in the past but that came into being a finite time ago. Moreover—and this deserves underscoring—the origin it posits is an absolute origin *ex nihilo*” (pp. 139–40). Copan and Craig also add thermodynamic arguments to bolster the claim of an initial singularity and a creation from nothing.

3. This idea of a creation from nothing contradicts Latter-day Saint beliefs about eternalism—the claim that God, human spirits, and even the elements are eternal. Therefore, claim Copan and Craig, to be included among Christians, Latter-day Saints must reject the doctrine of eternalism and adopt the doctrine of creation from nothing. Among the more memorable statements by Copan and Craig is the following:

The Big Bang represents the origin of all matter and energy, even of physical space and time themselves. . . . Therefore, to hold that matter/energy are eternal or that God is the physical product of a beginningless progression is irreconcilable with the theory. The problem posed by the Big Bang for Mormon theology is especially severe, not merely because the Big Bang theory supports creation *ex nihilo*, but because the Mormon concept of God as an extended material object existing in the universe requires, in connection with Big Bang cosmogony, that God himself (or his progenitors) came into being *ex nihilo*. Thus, Big Bang cosmogony is a veritable dagger at the throat of Mormon theology. (p. 146)

4. The Latter-day Saint concept of God as an embodied being existing in space and time subjects God to eventual destruction in the heat death of the universe.

Copan and Craig’s approach is scarcely dispassionate. They heap scorn upon the Latter-day Saint concept of deity. For example, they

title their chapter “Creator or Craftsman?” Given a choice, most folks (including Latter-day Saints) would, of course, choose to dignify God as a creator rather than a craftsman. In the Copan and Craig presentation, God is the creator because he brings entities like atoms, stars, and galaxies into being from nothing (absolute nothing), and in their view the Latter-day Saint God is (merely) a craftsman because he fashions entities like atoms, stars, and galaxies from preexisting pieces.

Where did Copan and Craig go wrong?

Let me say up front that in my opinion Copan and Craig went wrong in several significant ways:

1. Copan and Craig commit what I call the Aquinas fallacy. Seeing religious beliefs supported through scientific arguments reminds us that Thomas Aquinas used the scientific knowledge of his day, drawn principally from Aristotle, as a framework for his systematic theology. The resulting mixture of biblical teachings and Aristotelian science, often called scholasticism, was accepted and taught by Roman Catholics for centuries. It is still alive, though its scientific elements have had to be revised. The original acceptance of this doctrine led in the West to the sharp separation of science and religion into two distinct and often competitive enterprises. The Aquinas fallacy consists of assuming that current science, including both fact and speculation, provides final answers. I named the fallacy after Aquinas because of his prominence, but it could equally well have been named after any number of other figures—Jewish, Christian, and Muslim—who shared his presuppositions. Science, however, is an ongoing, self-correcting process leading to increased knowledge and understanding, and many wrong ideas are suggested and discarded before a corrected understanding eventually emerges.

Copan and Craig take the standard hot big bang model as a final scientific description of the origin of the universe and use it to establish a doctrine of “creation from nothing.” But the scriptures, I believe, were written with purposes rather different from the attempt to understand and explain the universe. It is essential to realize that both the scientific and the religious canons of knowledge are incomplete,

and it would be wrong to assume that either gives definitive answers about the other. While none can doubt the value of the knowledge and understanding brought into the world through science, one should be cautious in employing scientific results to support dogmas about God.

2. The scientific views of Copan and Craig are out of date. In their attempt to use scientific results, Copan and Craig employ the standard hot big bang cosmology that was current in the late 1970s, including a singularity at the origin of the universe, without understanding that quantum mechanics prevents a true singularity—a fact known much earlier. They also comment negatively on such important and well-accepted scientific ideas as vacuum energies and inflationary theories (the most popular version of which does not require a singularity). Furthermore, some other models of the early universe (including the no-boundary-condition model proposed in 1983 by Stephen Hawking and James Hartle,⁵ which Copan and Craig reject) do not have a singularity. Without the initial singularity, the claims of Copan and Craig have no scientific basis. Even if time had a beginning (which is still an open question), creation from nothing does not necessarily follow. A beginning of time means that we can make no measurements or observations regarding any earlier epoch, and the notion of time itself in our universe has no meaning before that moment.

Although it will likely remain forever undetectable, the multiverse (ignored by Copan and Craig but described below) is gaining acceptance as the “big” view of the universe(s). Some inflationary theories lead to a belief in continuous creation of universes, and these lead to a consideration of the biggest picture of reality: a multiverse, the totality of all universes, including the background energy of which they were made.⁶

5. See James B. Hartle, “Quantum Cosmology and the Early Universe,” in *The Very Early Universe: Proceedings of the Nuttfield Workshop*, Cambridge, ed. G. W. Gibbons, S. W. Hawking, and S. T. C. Siklos (Cambridge: Cambridge University Press, 1983), 59–89; and S. W. Hawking, “Euclidean Approach to the Inflationary Universe,” in *The Very Early Universe*, 287–96.

6. An extensive discussion of this view is found, for example, in Adams’s book *Our Living Multiverse*, chap. 2.

Copan and Craig do not mention the surprise discovery in late 1998 of the current acceleration of the expansion of the universe, apparently caused by an anti-gravity force similar to the huge energy of the vacuum or Einstein's cosmological term, and thus they neglect to note that this background energy alone may destroy the argument of creation from nothing. This discovery is discussed in most of the literature published since 1998. The omission is, incidentally, an excellent example of the Aquinas fallacy. As our knowledge of the universe changes, religious ideas tied to previous scientific knowledge become inadequate.

3. Copan and Craig confuse what might be called theological or philosophical *nothing* with scientific *nothing*. Theological or philosophical nothing refers to a totally empty space, which may not exist. Scientific nothing refers to the energy of the quantum mechanics vacuum or empty space, which is pictured as a scene of wild action and leads to an understanding of the birth and evolution of the universe. Although ignored by Copan and Craig, the energy of these huge fields is believed to provide the stuff of which the universe is made and is now observed to be the principal source of mass-energy of the universe. Had Copan and Craig provided a modern inventory of the universe, the overwhelming role of the mass-energy of the vacuum (now called dark energy) would have been *obvious*. In fact, the universe is made of about 5 percent common matter (electrons and protons), 25 percent "dark matter" (a mysterious matter whose nature is not understood), and 70 percent "dark energy" (a mysterious energy).

4. Copan and Craig unjustifiably conflate the creation account in Genesis 1:1 with the idea that the *entire universe* originated by *creatio ex nihilo*. "In the beginning God created the heaven and the earth"—so opens the creation story in the majestic prose of the King James Version of the Bible. From the start of the Christian era, the theological discussion of the world has always been focused on the earth and its associated heaven (the celestial sphere), which constituted the known world of the early church fathers.

The biblical account is a remarkably peaceful story. By contrast, the big bang is a story of incredible violence, involving inconceivable

forces and energies. It seems extremely unlikely that these two stories describe the same event, especially since the Bible deals specifically with objects and conditions on the earth. To read *universe* and *big bang* into the biblical creation account requires a spectacular leap of logic.

The biblical creation story describes the formation of earth and heaven at about the same time, but in reality they were formed at vastly different epochs. The history of the universe itself can be traced back about 14 billion years, and galaxies and stars have been forming ever since. The earth and sun were formed or created 4.6 billion years ago. The biblical story is not wrong; it is true to its purpose of presenting a symbolic account of the creation of this earth, and it should not be read as a scientific record.

To ancient people (and many people today), the sky (heaven) was a hemispherical dome rising above a flat and stationary earth, which naturally lay at the center of whatever world they could imagine. Sun, moon, planets, and stars were lights attached to (or shining through) the crystalline dome overhead. A few scholars have believed for at least the past two millennia that the earth was spherical, but even these were unanimous in viewing earth as the center of their world. Now, for the first time, scientists are beginning to understand the origin and evolution of planets, stars, and galaxies that stretch out billions of light years and reveal an expanding and accelerating universe.

Even when prophets glimpsed the magnificent universe beyond the earth, God's instructions always pertained exclusively to this earth and its not-always-righteous inhabitants. Indeed, Jesus himself often had difficulty teaching fellow humans to accept even such simple concepts as the fatherhood of God and the brotherhood of man. They could hardly have communicated more subtle information about the universe, nor was it important to do so.

What does it mean to create? Many Christians, including Latter-day Saints, believe that God organized already existing matter/energy into an earth and solar system. Other Christians (including Copan and Craig) take a different position, claiming that God first created everything—including matter, energy, time, and space—from nothing. Copan and Craig find support for their position in the Bible:

"Furthermore, the idea of *creatio ex nihilo* is implied in Genesis 1:1, since no 'beginning' for God is mentioned" (p. 111). But, since Genesis 1:1 refers to the earth, one ought to ask: Was the earth created from nothing? Certainly not! Based on massive amounts of empirical and theoretical evidence, scientists state that the earth was created from preexisting gas and dust (a conclusion with which Latter-day Saints would agree). The argument of Copan and Craig that the language of Genesis 1:1 ("God created the heaven and the earth") implies creation from nothing is puzzling. One might as easily say that Henry Ford created the Ford car—however, he did not create it from nothing.

5. Copan and Craig ignore relevant portions of the biblical account that conflict with their thesis. Christians must decide whether to accept the biblical age of the earth as a few thousand years or the scientifically determined age of 4.6 billion years. There is no middle ground, and the question of the age of the earth decisively divides Christians into two separate camps. If a person accepts the biblical age, on what basis does he or she reject the repeated, radioactively measured ages for terrestrial, lunar, and meteoritic rocks of many types as well as a host of consistent dates from chemical isotopic ratios, ice and mud cores, ages of stars and galaxies, fossils, and other measurements? On the other hand, if a person accepts the ages measured by scientists, how does he or she propose to treat the claims of dates and times attributed to the Bible? Christians (including Copan and Craig) who discard or rationalize away the biblical chronology (for example, by accepting the big bang 14 billion years ago) are left with no basis whatever on which to mount a biblical concept of creation. In particular, *it is illogical for Christians who have discarded biblical chronology to present a biblical argument for creation from nothing.*

How did the big bang begin?

In order to evaluate Copan and Craig's claims, it will be necessary to examine current thinking about the big bang. Let's extrapolate backward in time as the size of the universe decreases and density and temperature increase. According to theoretical estimates, one year after the beginning, the temperature of the universe was about 2 million K

(similar to the temperature of the solar corona) and the density was 10^{-9} grams per cubic centimeter (close to the figure for the surface of the sun).⁷ At one second after the beginning, the temperature was about 10 billion K (similar to the center of a supernova explosion) and the density about 500,000 grams per cubic centimeter (close to the density of a white-dwarf star).⁸ At earlier times, temperatures and densities were even higher, and such conditions are exciting to physicists because they allow the nuclear reactions that produce the lighter chemical elements and (for the grand prize of physics) the unification of forces (a topic that is beyond the scope of this article).

If one were to extrapolate mechanically to a beginning at $t = 0$, one would obtain for the universe a zero radius and infinite values of density, temperature, pressure, and energy. What happened before that instant would be completely unknown. Mathematical physicists Stephen Hawking and Roger Penrose showed that “the beginning of time would have been a point of infinite density and infinite curvature of space-time. All the known laws of physics would break down at such a point.”⁹ Such a point, as we’ve already seen, is called a singularity. While Copan and Craig accept the reality of this initial singularity and argue that it requires creation from nothing (p. 140), many physicists now reject two underlying assumptions of the Hawking-Penrose theorems: that the general theory of relativity holds everywhere and that the gravitational force is always attractive.¹⁰ Most scientists expect a quantum theory of gravity to supersede the general theory of relativity, and it was apparently the repulsive gravitation that drove inflation in the early universe. Rejection of these two assumptions undercuts Copan and Craig because the theory that required a singularity is no longer valid. Those who support “creation from nothing” must go hunting for new evidence.

7. Note that numbers in an exponent simply show the number of zeros after (+) or before (-) the given digits. For example, 10^5 means 1 followed by 5 zeros (100,000), and 10^{-9} means 1 preceded by a period and 9 zeros (.000000001).

8. Alan H. Guth, *The Inflationary Universe: The Quest for a New Theory of Cosmic Origins* (Reading, MA: Addison-Wesley, 1997), 86.

9. Stephen Hawking, *A Brief History of Time* (New York: Bantam, 1988), 133.

10. John D. Barrow, *The Book of Nothing* (London: Cape, 2000), 307.

What is wrong with the standard hot big bang model?

The standard big bang theory, with its initial singularity, was current up to the late 1970s, but it failed to describe adequately the earliest stages of the universe. This model made three empirically verified predictions: the universe is expanding (although this might be called a retrospective prediction or an explanation of the observed red shift of distant galaxies); the universe is swimming in greatly red-shifted radiation (the CMB radiation from the big bang); and the abundances of the light elements (deuterium, helium, and lithium) are observed to have the specific values predicted by the theory. Furthermore, certain observations that might have contradicted the model did not actually contradict it.

Since the standard hot big bang model really begins at an epoch (very shortly) after the beginning, it offers no hint as to the origin of the bang, and thus it lacks a preceding cause—a fact considered a serious deficiency by scientists, though apparently not by theologians. Furthermore, the standard big bang model suffered from at least three grave defects, any one of which constituted sufficient reason to reject it:

1. The universe appears roughly the same in all directions (even in opposite directions), yet there has not been enough time since the beginning of the universal expansion for these distant regions to have been in mutual communication (even at the speed of light)—that is, unless these now distant parts of the universe once shared the same laws and conditions (or “were in communication,” as scientists say). This is called the horizon problem.

2. As the initial expansion of space carried energy and matter outward, infinitesimally tiny density differences (differences so tiny they can only be imagined) from place to place would have been quickly and enormously amplified, and anything short of incredibly fine tuning would have produced far more structure (clusters of galaxies) than is observed (the smoothness problem).

3. Finally, there is the flatness problem. Most theories of the big bang yield an energy density of the universe exactly equal to the critical density needed for a “just open” universe (a universe that expands forever but whose expansion velocity constantly decreases), yet a careful

inventory of all the mass-energy in the universe, including dark matter (matter detected only by its gravitational signature), can account for only about 0.30 of the critical density. (As noted earlier, common matter accounts for about 5 percent of the total mass-energy and dark matter for 25 percent. Dark energy accounts for 70 percent.) Perhaps worst of all, the standard model provided no reason for the big bang to occur in the first place. In the late 1970s, scientists were understandably puzzled by the lack of explanations and solutions to these problems.

In the absence of scientific explanations, however, certain theologians jumped into the fray and declared that God initiated the big bang. In 1951, for instance, Pope Pius XII pointed to the big bang as the biblically described creation event.¹¹ Unfortunately, that claim is not a scientific explanation, as is evident if one asks what has been learned from that hypothesis.

Does the big bang support creation *ex nihilo* (creation from nothing)?

The fundamental question of what the big bang theory supports is closely related to, and often confused with, the question of the beginning of time. No statement can be made about the universe before the Planck time, 10^{-43} seconds after the beginning.¹² One cosmologist says simply, “The beginning of time is not defined.”¹³ As shown above, very little information is available before 300,000 years after the beginning, and, as described above, values of temperature, density, and energy become infinite (unlimited) if one tries to extrapolate back to time zero.

Regarding creation from nothing, physicist Fred Adams succinctly states: “The big bang does not represent creation *ex nihilo*. Cosmic history began at a particular point in time—the moment we denote as $t = 0$. But before that point we do not assume that there was nothing

11. Ian G. Barbour, *Religion in an Age of Science: The Gifford Lectures 1989–1991* (San Francisco: Harper & Row, 1990), 1:128; Victor J. Stenger, *Has Science Found God? The Latest Results in the Search for Purpose in the Universe* (Amherst, NY: Prometheus Books, 2003), 164.

12. See the section on quantum mechanics, below.

13. Adams, *Our Living Multiverse*, 38.

at all in existence. Energy is the currency of the cosmos, so this incorrect assumption would imply that an extraordinarily large violation of energy conservation took place at the beginning of time."¹⁴

Have we settled everything?

To better understand our remarkable universe and how its origin and evolution influence Latter-day Saint theology in a comprehensive and comprehensible way is a commendable goal, but it is beyond the scope of this paper. Such an undertaking is also not easy because our universe is such an astonishing place and because any discussion must confront new ideas, some of which may seem counterintuitive or may fly in the face of common sense. Let me begin with the most difficult—quantum mechanics (since nature seems to function in accordance with its laws).

What is quantum mechanics?

To understand the behavior of such tiny entities as photons, electrons, atoms, and the early universe, we must look at the strange world of quantum mechanics. Early in the twentieth century, such physicists as Max Planck and Albert Einstein demonstrated that light was not perfectly smooth, but had properties of a particle (called a photon) as well as a wave. Some years later, a converse realization took place—particles such as electrons, protons, and atoms show wave traits as well as particle traits. Surprisingly, even large objects (such as you and I) have a wave

14. Ibid., 38. Additional arguments against the theological concept of creation from nothing, based on considerations of entropy and the energy-density budget of the universe (including points directed specifically at Craig), are presented by physicist Stenger in his book *Has Science Found God?* Stenger answers his own question with a definite "no." Scientific and metaphysical arguments for and against our universe being a designer universe (designed by God) are further discussed in a variety of books by physicists, cosmologists, and theologians; see, for example, Paul C. W. Davies, *The Mind of God: The Scientific Basis for a Rational World* (New York: Simon and Schuster, 1992); Timothy Ferris, *The Whole Shebang: A State-of-the Universe(s) Report* (New York: Simon and Schuster, 1997); Russell Stannard, *The God Experiment: Can Science Prove the Existence of God?* (London: Faber and Faber, 1999); and Ian G. Barbour, *When Science Meets Religion* (San Francisco: HarperSanFrancisco, 2000).

nature, but it is not apparent in everyday experience because our wavelengths are so incomprehensibly short. The mathematical formalism that treats the combined particle-wave nature of things is called quantum mechanics, a strange view of the world that is far beyond the scope of this paper. Indeed, quantum mechanics remains the only theory or procedure that makes predictions regarding the interactions of such entities as photons and atoms. Furthermore, the predictions of quantum mechanics agree with nature to an astonishing degree of accuracy.

It is sufficient to note that everything in the universe—including energy, matter, space, and time—is ultimately discrete, not smooth and continuous; that is, all physical entities are made up of tiny pieces. Furthermore, quantum mechanics forbids any objects—because they are waves as well as particles—from being perfectly localized when we know something about their velocity. This is often expressed by the Heisenberg uncertainty principle (named after the German physicist Werner Heisenberg), which states that it is fundamentally impossible to measure to any desired precision at the same time the position and momentum (mass times velocity), or any such pair of variables (such as energy and time), of a single particle or object. Such knowledge, in which properties and predictions are exactly determined, is replaced in quantum mechanics by probabilities.

So-called classical theories in physics (theories without quantum mechanics), such as the theory of forces and motions and electromagnetism, have been reformulated in the twentieth century to harmonize with quantum mechanics. But one theory—general relativity—has resisted such reformulation, and we do not yet have a harmonious combination of general relativity and quantum mechanics. What does this mean? It means that the big bang and the beginning of the universe—the one situation in nature in which both these theories are important—cannot be fully explained by scientists today. Nevertheless, one can confidently assert, even in the absence of a complete theory, that, because fundamental entities or objects cannot be precisely localized, perfect singularities cannot exist. A perfect singularity is, by definition, a perfect point, and quantum mechanics does not allow this. Therefore, the universe cannot have begun at such a (non-

existent) point. There was always a finite extent to the material in the big bang, and the stuff had a very large, but finite, temperature and density. (Once again, quantum theory undercuts the “creation from nothing” arguments of Copan and Craig.)

The remark made above that perfect singularities cannot exist can be made quantitative. In our universe, both space and time are discrete on the smallest scales. Planck, the German physicist who first suggested that light is not perfectly smooth, also defined a system of natural units in which both the general theory of relativity and quantum mechanics play a role, and most physicists believe these to be the smallest possible pieces. The smallest unit of length (Planck length) is 10^{-33} cm, and the smallest unit of time (Planck time) is 10^{-43} seconds. Although these units are absurdly tiny by ordinary measures, they become important for events on microscopic scales and high energies, specifically including the big bang.¹⁵

What is “nothing”?

Now we consider another remarkable feature of the universe—the concept of nothing. Because of quantum mechanics, physicists view empty space quite differently from the absolute nothingness of theologians. One cosmologist remarks that the notion of a vacuum has undergone a greater change in meaning than any other word or concept in science. From something like an absolutely empty void, the vacuum has emerged as “a bubbling, brewing source of matter and energy; it may even contain most of the matter in the universe!”¹⁶ As time has passed, evidence from several sources has accumulated that some anti-gravity energy from the vacuum does indeed contain most (about 70 percent) of the mass-energy of the universe. (As is obvious,

15. Readers desiring to learn about quantum mechanics, M-theory, or various possibilities for the past and future of the universe might start with Stephen Hawking’s book, *The Universe in a Nutshell* (New York: Bantam Books, 2001), with its marvelous diagrams.

16. Lawrence M. Krauss, *Quintessence: The Mystery of Missing Mass in the Universe* (New York: Basic Books, 2000), 33.

a claim that scientific evidence supports the postulate of *creatio ex nihilo* must be received with great skepticism.)

Imagine a box one meter (or one yard) on each side sitting in empty space between the galaxies. What is the least it could contain? In fact, such a box would contain a menagerie of particles, waves, fields, energies, and interactions. For starters, it would contain a few atoms or ions, but let us imagine applying the best vacuum pump in the Milky Way Galaxy, a magic pump that can draw out every single atom. Would the box then be empty? No. The box would contain lots of electromagnetic waves or photons. If the walls of the box were opaque, they would radiate long-wavelength photons in thermal equilibrium with their surroundings. If the walls were transparent, dozens of photons of all wavelengths from stars in the Milky Way Galaxy would pass through the box. Finally, about a billion CMB photons from the big bang itself would be present in every cubic meter in our universe.

A box in intergalactic space is also bathed in cosmic rays of various energies and from all directions. Neutrinos (tiny neutral particles with extremely low mass and traveling near the speed of light) in at least three varieties constantly whiz through the box without noticeably interacting with anything else. Furthermore, some theories predict other weakly interacting particles flying about. Every photon or electromagnetic wave is a manifestation of combined, changing electric and magnetic fields. Other fields, such as gravitational fields, are always present, and these carry vast amounts of energy. Even if all particles and all electric and magnetic fields could magically be eliminated, gravitational fields apparently cannot be eliminated, even in principle.

Our story becomes stranger as we dig deeper. Any attempt to describe empty space is bound to fail unless it includes the quantum fluctuations of the vacuum, which form a background for everything else. Quantum mechanics imposes a rigorous upper limit to our knowledge because of the uncertainty principle. Even empty space—the vacuum—is a beehive of activity in which a froth of virtual particles, waves, and quasi-particles leaps into existence as a quantum fluctuation and then dissolves back into the vacuum or annihilates with corresponding anti-particles or waves (on time scales of about 10^{-22} seconds).

In quantum mechanics a certain amount of energy is *always* present. "This discovery at the heart of the quantum description of matter means that the concept of the vacuum must be somewhat realigned. It is no longer to be associated with the idea of the void and of nothingness or empty space. Rather, it is merely the emptiest possible state in the sense of the state that possesses the lowest possible energy: the state from which no further energy can be removed. We call this the *ground state* or the *vacuum state*."¹⁷ An imaginary region containing nothing at all would collapse to zero size.

Although vacuum fluctuations cannot be measured individually (and are therefore called virtual particles or waves), they can be measured indirectly through their influence on such other processes as the magnetic strength of an electron¹⁸ and the Casimir effect (a net inward pressure—from virtual particle pairs, or quantum mechanics waves—outside, felt by two parallel plates placed extremely close together.)¹⁹ These observed effects demonstrate the reality of vacuum fluctuations as described by quantum theory. In our physical universe, nothingness is an unrealizable fantasy. (To claim nothing exists somewhere outside our universe would be an additional postulate.)

Consider now a contour map of the universe or a piece of the universe, where the energy of the vacuum or empty space is the quantity plotted. On such a topographic map, energy is measured upward at every point. In this energy landscape, hills are regions of high energy while valleys are regions of low energy. The lowest point on the topographic map represents the true vacuum, where the energy is lowest—but not zero. One can now imagine that this map of the energy field represents the multiverse, out of which universes can form. As we attempt to visualize and discuss the big bang, vacuum energy, multiverses, dark matter, and the dark energy of the universe, this energy contour map will be of considerable help.

17. Barrow, *Book of Nothing*, 216.

18. Guth, *Inflationary Universe*, 272.

19. Hawking, *Universe in a Nutshell*, 46–47; Mario Livio, *The Accelerating Universe: Infinite Expansion, the Cosmological Constant, and the Beauty of the Cosmos* (New York: Wiley and Sons, 2000), 126.

In the *Book of Nothing*, mathematical physicist John Barrow describes the role of the vacuum:

We have seen how the vacuum energy of the Universe may prevent the Universe from having a beginning, may influence its early inflationary moments and may be driving its expansion today, but its most dramatic effect is still to come: its domination of the Universe's future. The vacuum energy that manifests itself as Einstein's lambda force stays constant whilst every other contribution to the density of matter in the Universe—stars, planets, radiation, black holes—is diluted away by the expansion. If the vacuum lambda force [or perhaps Einstein's cosmological term] has recently started accelerating the expansion of the Universe, as observations imply, then its domination will grow overwhelming in the future. The Universe will continue expanding and accelerating for ever.²⁰

One must therefore discard old and seemingly obvious ideas about nothing or empty space, which do not exist in our universe. In reality, empty space is filled with particles and waves, many of which we do not currently understand, and the mass-energy of empty space dominates our universe. It is difficult to imagine that nothing exists anywhere. Creation from nothing is clearly a fantasy devised by certain theologians, perhaps in a misguided attempt to glorify God by making of him a fantastic magician.

What is an inflationary universe?

An inflationary epoch that precedes the big bang expansion and then goes over to it (in a tiny fraction of a second) provides a much more satisfying description of the early universe than the standard hot big bang theory and is now widely accepted in general outline even as details of various models are being worked out. Inflationary scenarios retain the virtues of the standard big bang theory but avoid its flaws. Many inflationary models neither require nor allow an initial physi-

20. Barrow, *Book of Nothing*, 313–14.

cal singularity, and many of these predict a continuous formation of universes from the energy of the vacuum or empty space.

Inflation as a model for an extremely early epoch was formulated by Alan H. Guth, Andrei Linde, Paul Steinhardt, and others in the early 1980s; a description can be found in Guth's book, *The Inflationary Universe*. In Guth's early version of the theory, as the energy fields that would become a universe began to cool down in the first split second after the big bang, they landed in a state of false vacuum, a state of higher energy than the ground state, which is the true vacuum. (At this point it will be helpful to recall the topographic energy map described earlier. A false vacuum is a valley but not the lowest valley, which is the ground state.) From the false vacuum the universe made a transition to the true vacuum, releasing huge amounts of energy. Similar to a phase change in matter (gas to liquid or liquid to solid), the huge increase in energy from the downward transition resulted in an enormous expansion—by an unbelievably large factor of 10^{30} to 10^{50} —of the tiny piece of the universe that dropped down.

Linde, a Russian-American cosmologist, showed that a gentler slope in the energy map between hill and valley led to a more satisfactory transition to the standard big bang model. Linde also showed that the observed universe was likely only a tiny speck in a huge bubble, and Guth called this the new inflationary model.²¹ In his book, *Particle Physics and Inflationary Cosmology*, Linde shows that the big bang arises like chaotic foam from a complex of scalar fields (scalar fields, such as temperature, have magnitude but no direction).²² He calls his model chaotic inflation or eternal inflation because it continues to produce new baby universes, both from the background vacuum itself and from already extant universes.

Inflation lasted roughly from 10^{-37} to 10^{-35} seconds, such an inconceivably short fraction of a second that many people simply throw up their hands and walk away rather than seriously trying to comprehend it. However, important events can transpire on such short

21. Guth, *Inflationary Universe*, 206–7.

22. Andrei D. Linde, *Particle Physics and Inflationary Cosmology*, trans. Marc Damashak (Chur, Switzerland: Harwood Academic, 1989).

time scales. Inflation succeeds because it is much faster than other processes, including vacuum fluctuations. Inflationary models retain the virtues of the standard big bang model (since they later go over to it) but provide a deeper understanding of the very earliest phases of the universe (though later than the Planck time). Guth notes the vast difference in size between the observed universe (the universe we see) and the actual pocket or bubble universe (the bubble that inflated from the vacuum). Our observed universe continues to increase in size, partly by its expansion and partly by the arrival at the earth of radiation from previously unseen parts of the universe (bodies so far away that their light had not had time to reach us), but one can never hope to see all of the actual or bubble universe.²³

What is the effect of this new understanding? “Some universes with gravitationally repulsive matter still have beginnings where the density is infinite, but they don’t need to. We have already seen one spectacular example that appears to evade the need for a beginning. The self-reproducing eternal inflationary universe almost certainly has no beginning. It can be continued indefinitely into the past.”²⁴ If scientists succeed in explaining the universe by the underlying laws of nature, the implications are dramatic. “We would have accomplished the spectacular goal of understanding why there is something rather than nothing—because, if this approach is right, perpetual ‘nothing’ is impossible.”²⁵

Although something like inflation and the big bang occurred very early in our universe’s history, much of our understanding is still quite tentative, and dozens of different suggestions, scenarios, and theories for the beginning of the universe have been offered.

23. More detailed information on the inflationary universe can be found in the note references in this article, as well as in Brian Greene, *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory* (New York: Norton, 1999); and Martin J. Rees, *New Perspectives in Astrophysical Cosmology*, 2nd ed. (New York: Cambridge University Press, 2000).

24. Barrow, *Book of Nothing*, 307.

25. Guth, *Inflationary Universe*, 276.

What is string theory?

Another broad group of theories—called collectively string theory or M-theory, in which the basic units are tiny vibrating strings instead of particles—has potential for explaining the existence of particles, forces, dimensions, the big bang, and possibly the universe itself.²⁶ In some sense, M-theory is an attempt to combine quantum mechanics and the general theory of relativity—the twin pillars of modern physics, and most physicists believe a unification is necessary and possible.

A new version of M-theory, which includes multidimensional membranes (branes or p-branes), so that strings are branes of dimension $p = 1$, has revitalized the field. Perhaps the big bang was the collision of two branes (the so-called ekpyrotic theory).

While many physicists are skeptical, proponents of the new string theory exuberantly call it TOE (the Theory of Everything). New ideas, theories, or models may yet be announced in the future because many puzzles remain unsolved. Science is a search that never ends, and we must be prepared for new and sometimes strange ideas. Any of these could put the question of the origin of the universe in an entirely new light. The seeming dogmatism of Copan and Craig is, thus, fundamentally alien to the scientific study of the origin of the universe.

Where does all the stuff come from?

I will try to keep it simple. Total energies become a bit uncertain in an expanding and accelerating open universe. Recall that the total energy (E) of a system is comprised of its kinetic energy (T) and potential energy (V), so that $E = T + V$. The potential energy includes the energy of all fields in the universe (such as gravitational energy, stored in empty space), and the kinetic energy includes not only the energy of motion of all galaxies but also the rest-mass energy of all particles ($E = mc^2$). Recall also that the potential energy is negative.

26. Brian Greene, *The Fabric of the Cosmos: Space, Time, and the Texture of Reality* (New York: Knopf, 2004), chap. 12; Hawking, *Universe in a Nutshell*.

Strangely, for the entire universe, it appears that these two enormous quantities, T and V , are almost exactly equal but opposite in sign, so their sum is very close to zero. Stated differently, energy for the grand spectacle of creation—atoms, stars, and galaxies—is provided at the expense of an increasingly large negative energy due to various fields stored in empty space (the vacuum or the cosmological term). In a financial parallel, it is as if one could spend whatever one wanted by going deeper and deeper into debt (so that the sum of the debts always balanced the value of the stuff), but without anyone being called to account. We humans live in a very strange universe.

Let us look at the strange mixture. Stars, planets, trees, and humans are made of atoms, and atoms are made of protons, neutrons, and electrons. We might expect the entire universe to be made of the same stuff. Astonishingly, it is not so. These particles constitute only about 5 percent of the total mass of the universe. An additional 25 percent is comprised of what is called dark matter—matter that is not seen but is detectable by its gravitational influence. Most of the universe, about 70 percent, is made of what scientists term dark energy, whose nature is unknown but which is likely related to the energy of the vacuum or Einstein's cosmological term.

How is energy stored in a field? Where is gravitational energy stored? A stone lifted into the air, for example, has additional potential energy that could be released as kinetic energy if the stone fell. Where is the energy stored? Not in the stone. It is stored in the gravitational field—in empty space or the vacuum. Such a field is not easy to visualize, but it might help to recall a magnetic field, whose force we can actually feel and whose energy is stored in space.

Astrophysicist Sir Martin Rees puts it this way:

It may seem counterintuitive that an entire universe at least 10 billion light-years across (and probably spreading far beyond our present horizon) can have emerged from an infinitesimal speck. What makes this possible is that, however much inflation occurs, the total net energy is zero. It is as though the universe were making for itself a gravitational

pit so deep that everything in it has a negative gravitational energy exactly equal to its rest-mass energy (mc^2).²⁷

Perhaps surprisingly, the energy of the vacuum is negative, and it exerts a negative pressure, with the result that the gravitational fields (remember that energy exerts a gravitational force) are repulsive instead of attractive. This (outward) gravitational force pushes the expansion and inflation of the universe. It can be identified with the cosmological term because it acts as an anti-gravity force. The combination of vacuum fluctuations and inflation therefore provides a reason or cause for the big bang.

What is the heat death of the universe?

Energy always flows from a region of higher temperature to one of lower temperature. Applying this concept to the entire universe, scientists note that, as eons of time roll by, all bodies will reach the same temperature, and all action, motion, and energy flow will cease—a process popularly called *heat death*. Copan and Craig claim that the God of Mormonism, who is within the universe and subject to natural law, might also perish (“a pitiable deity,” they chortle, p. 147).

From a human perspective, the future of the universe seems grim indeed. Over billions of years, the remaining gas and dust in the Milky Way Galaxy will be converted into stars. Over a period of tens of billions of years, the stars will eventually burn out. As the acceleration of the universe continues, distant galaxies will disappear from view, communication will be lost, and a dark, cold acceleration death or heat death will occur.²⁸ No one can predict what will happen to intelligent life, but only a mighty effort by a unified and righteous earthly civilization could be expected to call down blessings from heaven to extend our civilization. Or, perhaps something totally different and better is in store.

27. Rees, *Before the Beginning*, 169.

28. As emphasized, for example, by Fred Adams and Greg Laughlin in their book *The Five Ages of the Universe: Inside the Physics of Eternity* (New York: Free Press, 1999).

Interestingly, the increasing brightness of the sun, ignored by Copan and Craig, will present an even earlier peril. Here's the story. Like all stars, the sun is burning its nuclear fuel (converting hydrogen to helium by nuclear fusion) and is on its way to become a red-giant star. Over a few billion years, its outer layers will expand and cool (become redder) and its total radiation will increase until it boils away earth's atmosphere and oceans. Eventually the sun will throw off about half its mass to reveal an extremely hot, compact core and flood the earth with ultraviolet radiation. As the sun's mass will then be less, the orbit of the badly burned earth will increase in size until it is nearly as big as the present orbit of Mars. Having no more nuclear fuel, the sun, over billions of years, will radiate away its store of thermal energy, cool down, and grow dim.

Assuming that we still exist as mortals by then, humans will face the red-giant peril long before any effects of the heat death. Survival will require that we alter the evolution of the sun or find a way to protect ourselves, perhaps by leaving the solar system. Clearly, either will require enormous blessings from God as well as a united and righteous effort far beyond anything we humans have yet produced.

What is a multiverse?

Consider a vast (endless) reservoir of vacuum energy (due to various fields, including gravitation), characterized by the appearance and disappearance of virtual particles and waves. Call this the *multiverse*. Tiny universes continually pop into existence, both from extant universes and from the multiverse. Most of these baby universes quickly vanish again into the vast reservoir, but some inflate to enormous sizes. Bubble universes do not interact with one another, and there is no way for our observed universe to communicate with the rest of our bubble universe. The astute reader will recognize the similarity between the creation and evolution of universes in the multiverse and the creation and evolution of galaxies in the universe in the steady-state theory.²⁹

29. Whimsical sketches of universes within a possible multiverse adorn the cover of Adams, *Our Living Multiverse*.

New universes may form continually. "The process [of creating universes by inflation] does not stop here [with our universe], but goes on forever, producing an infinite number of pocket universes at an ever-increasing rate. A fractal pattern is created, meaning that the sequence of false vacuum, pocket universe, and false vacuum is replicated on smaller and smaller scales. Thus, a region of false vacuum does not produce merely one universe, but instead produces an infinite number of universes!"³⁰ (A fractal pattern is one that reproduces itself on all size scales—that is, a bit like a tree, where limbs branch off a trunk, smaller limbs branch off these, and smaller limbs continue to branch off. Mathematically, this process could continue indefinitely.)

Since we cannot know of the existence of other bubble universes, why should we believe in their existence? Although these theoretical predictions stand forever outside our ability to verify or falsify directly, the fact that other predictions of these same theories explain a number of previously unexplained features of our own universe provides significant support for them. (As the reader will see, cosmology borders on metaphysics and seeks to answer very difficult questions, and, as already noted, incomplete answers to some questions may be the best scientists can do.)

One of the coauthors of inflationary cosmology explains the vast ramifications of this idea. "If inflation is correct, then the inflationary mechanism is responsible for the creation of essentially all the matter and energy in the universe. The theory also implies that the observed universe is only a minute fraction of the entire universe, and it strongly suggests that there are perhaps an infinite number of other universes that are completely disconnected from our own."³¹

Universes that bubble up from the multiverse might differ greatly from ours in their force constants or natural laws. If so, most would quickly disappear, and only a very few would have properties that allow for the formation of atoms, stars, life, and intelligence. On the other hand, other universes may be constrained by natural laws. Physicist

30. Guth, *Inflationary Universe*, 247, emphasis deleted.

31. *Ibid.*, 15.

Lee Smolin has speculated that new universes might pop up from black holes, and the attributes (dimensions, natural laws, and force constants) of a new universe might be similar to those of its mother universe. If so, universes able to form black holes would acquire a selective advantage in the survival of the fittest among universes. Most black holes are formed from the collapse of giant stars, and giant stars imply natural laws similar to those in our universe, where giant stars and sentient life exist. Smolin's far-out suggestion thus provides a mechanism for producing a large number of universes that are favorable to life, even intelligent life.³²

Do we live in a runaway universe?

For seventy years following Hubble's discovery of the universal expansion, scientists naturally assumed that the expansion was slowing down (decelerating) due to the combined gravitational attraction of all galaxies. The speed of a stone thrown upward steadily decreases until it stops and falls back down because we humans can't throw it with enough speed to escape the earth's gravity. For decades, a central question of cosmology was whether the universe would ever fall back down. Would the universe recollapse into a big crunch or continue to expand at a decreasing rate? Definitive measurements always seemed just out of reach.

However, in late 1998 two different teams of scientists reported their results on the search for the deceleration of the universe through observations of Type Ia supernovas—the (nuclear) explosions of gas captured from giant stars by their white-dwarf companions—with the Hubble Space Telescope. Since the explosion is triggered when a fixed amount of gas has been captured, all explosions release about the same energy, and the supernovas are therefore all about the same brightness (or can be corrected to be the same), and they are therefore good standard candles (objects of known brightness and therefore good distance indicators). Astonishingly, the measurements showed that the univer-

32. Lee Smolin, *The Life of the Cosmos* (New York: Oxford University Press, 1997), 91–93; Greene, *Fabric of the Cosmos*, 369.

sal expansion was now *speeding up* instead of *slowing down*! That is, galaxies are flying away from us with increasing speeds. It is as if a stone thrown into the air sped up as it rose into the sky. Unless the carefully observed data are somehow wrong or an alternative explanation can be found, these observations demonstrate a repulsive gravity that is operating to cause the speedup. To be more specific, evidence from supernovae and other observations indicates a slowing down during the first half of the life of the universe and a speeding up since then.

What existed before the big bang?

Twenty-five years ago physicists would not have asked that question because unanswerable questions are considered outside the realm of science. Now, at least an idea of what might have preceded the big bang is possible. This enormous change in attitude is seen in the fact that Rees writes a book with the title *Before the Beginning*, Guth expresses his views in the citation at the beginning of this article, and Adams titles a book *Our Living Multiverse*. Interesting as these ideas are, however, let us admit they are only suggestive possibilities.

What could have existed before the big bang? (1) Although based only on theoretical ideas, the multiverse is postulated to exist before the big bang. While it is difficult to imagine any direct evidence for anything outside our universe, good theoretical reasons support a belief in such an overarching entity. With its hills and dales of quantum mechanical energy (recall the energy topographical map), the multiverse appears to be (and to have always been) an endless background of energy for whatever else exists. (2) Since there is no reason to imagine that ours is the first bubble universe, a multitude of other bubble universes as well as multitudes of failed universes might have existed as well. Indeed, as noted above, some theories of inflation lead naturally to a continuous creation of universes. (3) Some believers would add God to the list, and Latter-day Saints might also add the spirits of mankind. (4) Is it conceivable that dimensions, natural laws, mass-energy, and wave functions existed as well? How we wish we understood our magnificent multiverse more thoroughly! (Readers should note that our present knowledge and understanding of many of these

points are rather primitive, and that these possibilities are only suggestions meant to stir thinking.)

How long is eternity?

Since the Church of Jesus Christ of Latter-day Saints teaches the eternity of human spirits, we briefly discuss eternity within an expanding universe and its possible meanings for God and mankind. Words such as *beginning*, *end*, *eternal*, *endless*, *everlasting*, and *infinite* are so freighted with various meanings that they should be carefully defined when used. For example, people speak of the “everlasting hills” even though those hills have not always existed and are eroding away as others are being uplifted, and lovers always describe their passion as eternal. The words *everlasting* and *eternal* are often used in a poetic sense and are not meant to be scientifically accurate. In many scriptures, writers are praising God, not giving hard information.

How long is eternity? Theologians can speculate forever, while scientists continue to provide a factual time line.

On the basis of both ancient and modern scripture, Latter-day Saints teach that human beings existed in some real but spiritual form before they were born into mortality. Joseph Smith declared: “There is no such thing as immaterial matter. All spirit is matter” (D&C 131:7). However, we know very little about the nature of spiritual matter, how spirits interact with physical matter, or how spirits existed before their entrance into human (mortal) bodies. The human spirit or intelligence is said to be coeternal with God; that is, it has existed for as long as God has existed (see D&C 93:33–34). Likewise, the elements (mass-energy) are said to have the same duration.

What does the key word *eternal* mean? There are several possibilities. (1) *Eternal* might simply mean “from here on.” After all, the future is enormously longer and more important than the past. (2) *Eternal* might mean “over the past 14 billion years and indefinitely into the future.” (3) *Eternal* might mean “from long before the big bang and indefinitely into the future.” All entities—physical or spiritual—must logically either have existed (in some form) before the big bang

or must have come into existence at or after the big bang. To exist beyond a few billion years into the future, any entity must be able to survive the red-giant stage of the sun and the bleak future of the universe. However, let us recall that Mormons are practical people who are committed to their church doctrines because they provide practical solutions. Church teachings help us in our daily life as well as in our long-range, spiritual perspectives, and they are optimistic about our unknown future. Clearly we have much to learn from both science and revelation.

What can Latter-day Saint thinkers contribute to cosmology?

To scientists, the word *cosmology* includes everything visible, measurable, or detectable by any means, from the very smallest unit to the entire universe and multiverse. This list includes the complete range of entities—matter, energy, space, time, forces, laws, dimensions, and consciousness—and their interactions. Even such strange concepts as dark matter, dark energy, the multiverse, and times before the big bang are part of cosmology.

Theology is usually understood to describe the study of God and spiritual matters. It includes ideas regarding the existence, attributes, and actions of God(s), angels, and spirits, as well as their interactions with each other and with humans. Theology also includes notions of life before and after mortality, sin, redemption, atonement, salvation, exaltation, judgment, and divine punishment. Christian theology also includes the premortal existence, birth, ministry, redemption, crucifixion, resurrection, and glorification of Jesus. Religion includes theology but emphasizes laws for human behavior, both toward God and toward others.

A Mormon cosmology ought to relate Latter-day Saint doctrines of God, spirits, revelation, and resurrection to the physical world. All truth must come together, but of course that will happen only in God's time. After we have understood and obeyed the commandments already given, we may receive more light. Clearly we have far to go.

Despite writings by several Latter-day Saint authors (including the groundbreaking book by Erich R. Paul,³³ a few other books and articles,³⁴ contributions in the book *Of Heaven and Earth*,³⁵ and this present article), no well-defined field of Latter-day Saint cosmology exists. Perhaps our knowledge of the physical universe and of Latter-day Saint theology will never be sufficiently complete to allow it in this life. Cosmology itself will likely never be complete. In the meantime, let us be optimistic. The freedom to study, think, pray, experience, and learn without rigid doctrinal guidelines is priceless. At the same time, Latter-day Saint doctrines can greatly enrich the joy of the journey.

To some observers of Mormonism, including Copan and Craig, Latter-day Saint doctrine occasionally seems fluid or changeable (pp. 148, 152). That is a common misunderstanding. Mormon doctrines are generally based upon broad principles with sources in the Bible, other scriptures, and the statements of modern prophets. These are sufficient for happiness, salvation, and exaltation. Most Latter-day Saints—busy with homes, families, communities, temples, preaching the gospel, and building the kingdom—have not seen the need for a carefully thought-out or rational cosmology. Consequently, loose ends may appear everywhere, and different Latter-day Saint scholars may express somewhat differing views, naturally giving the appearance of fluidity.

Since Copan and Craig's claim of creation from nothing—the heart of their theology—depends on the standard big bang model, they naturally flail away at the views of Mormon writers who have attempted to defend Latter-day Saint doctrines or explore other cosmologies. However, to reject the contributions by Latter-day Saint

33. Erich Robert Paul, *Science, Religion, and Mormon Cosmology* (Urbana: University of Illinois Press, 1992).

34. See David H. Bailey, "Scientific Foundations of Mormon Theology," in *The Search for Harmony: Essays on Science and Mormonism*, ed. Gene A. Sessions and Craig J. Oberg (Salt Lake City: Signature Books, 1993), 1–16; Duane E. Jeffery, "Seers, Savants, and Evolution: An Uneasy Interface," *Dialogue* 34/1–2 (2001): 183–224, originally appearing in *Dialogue* 8/3–4 (1974): 41–75.

35. David L. Clark, ed., *Of Heaven and Earth: Reconciling Scientific Thought with LDS Theology* (Salt Lake City: Deseret Book, 1998).

scholars out of hand is misguided. Cosmological ideas expressed by Latter-day Saint thinkers are perhaps best regarded as thoughtful suggestions rather than definitive proclamations, and such thinking should be encouraged. Like their fellow Christians, most Latter-day Saints are likely unfamiliar with details of the big bang, and it does not affect their daily lives. *Righteous living is very important to Latter-day Saints, but theology is far less so.*

A study presented by B. Kent Harrison and Eric Hirschmann at the 2002 meeting of the Mormon History Association reviewed Latter-day Saint views on creation through the nineteenth and twentieth centuries as stated in such sources as the *Journal of Discourses*.³⁶ While they discussed the creation of the earth from preexisting matter, they said practically nothing about the creation of the entire universe. Indeed, the very concept of the universe, as we understand it, did not exist in the nineteenth century. A Latter-day Saint cosmology as described above did not exist.

Although Latter-day Saint thinkers are just beginning to establish a true Mormon cosmology, which includes knowledge from science and from divine revelation, we encourage that endeavor. Latter-day Saint theology is as complete as is needed, and we believe that additional revelation will point the way ahead.

What is the relation between God, the universe, and natural law?

God is immensely powerful and glorious, but can his power and glory be measured? Over what realm of space-time does God reign? Where and when did God pass through mortality, receive a tangible body, and then obtain resurrection and glorification?

A fundamental cosmological problem is to relate an unchanging God to an evolving universe having a beginning. Although this was not the original reason, an approach taken by many Christians is to place God outside the universe, where God remains distinct and

36. B. Kent Harrison and Eric W. Hirschmann, "Astronomy and Cosmology in Mormon Scripture and Thought" (paper presented at the meetings of the Mormon History Association, Phoenix, AZ, 18 May 2002).

isolated from the turmoil of the universe with its load of stars and human beings. Since God is outside the universe and unchanging, he is claimed to be spiritual and not material.

Copan and Craig seem almost to turn the argument around. They state: “To explain the origin of the universe *ex nihilo*, such an ultra-mundane being [God], as the cause of space and time, must transcend space and time and therefore exist atemporally and nonspatially, at least sans the universe. This transcendent cause must therefore be changeless and immaterial, since timelessness entails changelessness, and changelessness implies immateriality. Such a cause must be beginningless and uncaused” (p. 145). It thus appears that Copan and Craig take the existence of creation *ex nihilo* as the most fundamental theological “fact” and deduce the existence of an omnipotent and unchangeable God as something required to carry out the task of creation from nothing.

While Latter-day Saint doctrines are genuinely biblical, they are often elaborated more fully in distinctive Latter-day Saint scriptures and in the teachings of modern Latter-day Saint prophets than they are in the Bible itself.

1. In company with many religious believers, Latter-day Saints believe that each human being has or is a spirit that, during this present (mortal) life, is associated with (“clothed with”) a material body.

2. Just as Jesus existed before his appearance in mortality, human spirits also enjoyed a premortal existence. Furthermore, the spirits of human beings are literal children of God, our Father in Heaven. Humans and God are of the same family.

3. As Son of God, Jesus lived as a man on this earth, taught the gospel, set a perfect example of service to God and his fellow humans, took upon himself the sins of all mankind, was crucified, died, and was physically resurrected and glorified by God, our Heavenly Father. Jesus will naturally retain his resurrected and glorified body forever.

4. Because Jesus was resurrected, all humans will subsequently be resurrected.

5. Humans can become godlike and should strive to do so. Jesus taught and showed the only true way through obeying all God’s commandments and demonstrating charity toward all mankind.

6. Jesus followed in the footsteps of his Father in Heaven, who, eons ago, was resurrected and glorified and who retains his tangible body of flesh and bone and now governs worlds without number.

7. Because we are his children, God loves all humans, and he commands, encourages, and guides people today through inspiration and revelation.

Joseph Smith proposed the radical idea³⁷ as it was put into a poetic form by President Lorenzo Snow: “As man now is, God once was: As God now is, man may be.”³⁸ That is, human beings are of the same family—which is to say that they are ontologically similar—and on the same track through life and eternity as God, but that God is an unfathomable distance ahead of us. God’s love for his children is so great that they are his foremost concern, as magnificently stated in a scripture highly esteemed by Mormons: “For behold, this is my work and my glory—to bring to pass the immortality and eternal life of man” (Moses 1:39).

Summary

A fascinating concept, the big bang inspires questions of interest to everyone, and I have therefore discussed it in considerable detail, including observations on its aftermath, how it started, what existed before it, and the future of the universe it created. The biblical story of creation and the scientific story of the big bang appear to describe completely different events. Armed with this information, I pointed out several defects in the attempt by evangelical scholars such as Copan and Craig to use scientific results (often outdated) to reinforce their ideas of creation out of nothing and to poke fun at Latter-day Saint theology.

To place the big bang in a larger context, I discussed modern ideas of the strange quantum mechanics vacuum, and these ideas provide

37. See, for example, the King Follett discourse and Joseph Smith’s discourse on the multiplicity of Gods, specifically *Teachings of the Prophet Joseph Smith*, sel. Joseph Fielding Smith (Salt Lake City: Deseret Book, 1976), 345.

38. See Francis M. Gibbons, *Lorenzo Snow: Spiritual Giant, Prophet of God* (Salt Lake City: Deseret Book, 1982), 29; and Eliza R. Snow, *Biography and Family Record of Lorenzo Snow* (Salt Lake City: Deseret News, 1884), 46.

an entirely new view of nothing, and creation from nothing, a doctrine accepted by many Christians (including Copan and Craig) but rejected by many others, including Latter-day Saints. One of the strange features of our universe is the existence of vast amounts of energy in empty space or the vacuum. All the stuff of the universe—stars, galaxies, and us—apparently came from, and therefore increased, the enormous (negative) energies of empty space, which now seems to be pushing the acceleration of the universe.

The distant future of the universe appears gloomy in the extreme, and this grim future will be made up close and personal for earth-dwelling humans by the coming evolutionary changes of the sun as its radiation makes earth uninhabitable. The future is unknown, but much effort and enormous blessings from God will be sorely needed for humans to survive these challenges.

A full Latter-day Saint cosmology ought to bring together Latter-day Saint theology and scientific knowledge of the physical universe, but our knowledge of both is at present too scanty to create a cosmology. Through this article I hope to encourage Latter-day Saint thinkers. At the same time there is a danger that steps toward such a rational cosmology might be misperceived by some as genuine Latter-day Saint doctrine, which comes by divine revelation to prophets and is accepted by common consent of the members.

Our magnificent universe had a remarkable beginning as well as a marvelous development that has, after fourteen billion years, brought us to the present moment, where conscious and intelligent beings on a blue planet can ponder and pray about such matters. Let's enjoy the incredible journey!