Facing Up to Big Bang Challenges

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What danger lurks in associating big bang cosmology with biblical cosmology? Most Christian physicists, astronomers, and other scientists would say, "None." Many Christian philosophers, theologians, pastors, and other nonscientists would say, "A big one." The difference in these answers reveals a core difference in the way the two groups think and talk about scientific theories and Christian apologetics.

The chief concern on the part of nonscientist Christians, aside from the obvious challenge big bang cosmology presents to recent-creationist time scales, arises from the uncertainty and changeability of scientific theory. The risk is that of "overthrow by association." In other words, if a theory becomes closely associated with Scripture and that theory is overturned, the overthrow might be touted far and wide as the overthrow of biblical authority. Skeptics and atheists could then claim a reasonable excuse for their resistance to faith in Jesus Christ.

This fear has been reinforced more than once in history. The progress of science has seen the overturn of theory after theory through several centuries of research. It would seem, then, that theories in general cannot be trusted. More to the point, defense of a flat Earth (not necessarily by Christians) and of an Earth-centered universe, for example, as *biblical teachings* undermined the faith of many and salved the conscience of others when these "scientific" notions proved untrue. In truth, however, such ideas were never established scientifically. They stood on tradition and limited sensory data. Nor were such ideas established biblically, for they rested on simplistic exegesis of one or two verses. An integrative, systematic study of Scripture shows that a spherical Earth and a moving planet make a better fit with the biblical data. The sources of danger may be identified, then, as uncertain science and crude exegesis.

Christian apologists trained in the physical sciences and familiar with the Scriptures see no danger in connecting big bang cosmology with biblical teaching because the connection is based on well-established, thoroughly tested science and clear exegesis. Further, they understand that big bang theory refers not to one particular scenario but rather to a whole class of cosmological models. Understanding this one point may be the key to dispelling big bang phobia among Christians unfamiliar with science.

Each reported "overthrow" of the big bang represents merely the elimination of one or more of the subset of models, bringing greater refinement to the model as a whole. This process of elimination resembles the play action in the game of "Clue" in which the murderer, weapon, and location are determined by eliminating the other options.

Distinguishing features of the set of big bang models include, among others, these two: 1) the cosmos is traceable in finite time to a transcendent (from beyond the cosmos, i.e. from beyond matter, energy, and even the space-time dimensions associated with matter and energy) creation event and hence to a transcendent *Cause*, and 2) the universe is expanding (thus, cooling) with respect to time (Figure 1). Through the past hundred years of research, scientists have amassed a wealth of theoretical and observational evidence substantiating these two features of the cosmos.[1, 2] The certainty of their findings matches the certainty of astronomers that Newton's laws of motion will accurately describe the trajectories of spacecraft within our solar system.

Students of the Bible recognize these two features as part of God's special revelation about the universe. Of all the characteristics Scripture ascribes to "the heavens and the earth," these two stand out unmistakably: 1) the cosmos was created from beyond its own matter, energy, space, and time by a transcendent Being, and 2) the universe is expanding, "stretching out" through time.

Thousands of years before scientists had a clue, five Bible authors, from different eras and backgrounds, made reference to the first characteristic.[3,4] Five more authors, also from different times and places, made repeated reference to the second.[4,5]

Confusion about the certainty of the big bang perhaps arises from popular awareness that the theory still faces its challengers. While some of these challengers may be motivated by a desire to escape the big bang's theological implications, one must not assume that of all. In their pursuit of truth about the natural realm, scientists sometimes propose extremely improbable models in the hope of stimulating new and more exhaustive research. In the case of the big bang, the exercise of disproving various alternative models has typically led to deeper understanding of and greater confidence in the class of big bang models well supported by research data.

Fakir's No-Beginning Model

Among the theoretical challenges to a transcendent cosmic beginning recently appearing in the astrophysical literature, one challenge actually comprises a cluster of hypotheses, all introducing some unknown, undiscovered physical force or function.[6-8] Each is a variation on the theme of hypothesizing some new physics to alter in some way the physics scientists now measure and understand. If the trend line of the past several decades holds true, one can anticipate that the attempts to find supporting evidence for these hypotheses will yield, instead, clearer and stronger evidences for the Creator.

Redouane Fakir, a cosmologist at the University of British Columbia, recently published an article in the *Astrophysical Journal* entitled "General Relativistic Cosmology With No Beginning of Time."[9] The author admits he chose the title for its shock value. Fakir's paper begins with a review of singularity theorems, which establish the necessity of a transcendent Cause for the universe.[10-16] The article affirms (and documents) that these theorems prove a "singular" beginning for the cosmos, whether governed by classical general relativity or by inflation (hyperexpansion of the universe during a finite period when the universe is younger than 10^{-32} seconds). Fakir also notes that the usual alternatives to general relativity—namely, scalar tensor theories of gravity (see "What Is A Scalar Field?" page X)—either produce unstable solutions or demand conditions contradicted by confirmed observations.

Nevertheless, Fakir boasts in his abstract that his cosmic model is "naturally free of singularities" despite its reliance on classical general relativity.[17] Free of singularities implies a "no beginning" model, but a careful read of Fakir's paper reveals, rather, a multiple beginnings model. Specifically, Fakir attempts to revive the oscillating universe model of the 1970s with its infinite cycles of cosmic expansion and contraction. Fakir's model looks roughly like this: the universe contains enough mass to put the (gravitational) brakes on cosmic expansion and, eventually, to reverse it (Figure 2). Oscillation is achieved by introducing a time-varying scalar field. (Fakir's model, therefore, is *not* based on classical general relativity.) During the contraction phase of the universe, the scalar field would gradually grow, ultimately becoming strong enough to reverse the gravitational collapse.

By Fakir's own admission, the cosmic re-collapse occurs in too brief a time to allow star formation—unless one acknowledges *extra* fine-tuning in a number of cosmic parameters.[18] In other words, though the model seems to diminish or relegate to the very distant past God's role in fine-tuning the beginning, it suggests an increased divine role in its ongoing maintenance.

Little if any need remains, however, to test Fakir's model or the others like it. The thermodynamic state of this universe or of any universe capable of sustaining physical life will not permit a cosmic bounce either in the past or the future.[19,20] In addition, new maps of temperature fluctuations in the cosmic background radiation combined with measurements on distant type 1a supernovae (Figure 3) verify that cosmic expansion has transitioned from a gradual deceleration to an exponentially increasing acceleration.[21-23] In other words, the universe has been continuously expanding since the beginning of the universe, and it will continue to expand at an increasing rate. Nothing but the power of God can stop it.[24]

Alternative Scalar Fields?

The proposal of some kind of scalar field to modify or replace general relativity (hence, the beginning) is not new. Einstein himself made such a proposal in 1917.[25] So did the British mathematician Arthur Eddington in 1930 and Carl Brans and Robert Dicke in 1961.[26, 27] All such proposals have been struck down by observational research. In particular, the sun's spherical shape, neutron star dynamics, the cosmic mass density (a measure of the total amount of matter, both ordinary and exotic,[28] in the universe), the cosmic space energy density[29] (a measure of the self-stretching property of the space manifold or space fabric of the universe), and the cosmic baryon density (a measure of the number of protons and neutrons in the universe) all place tight limits on the degree to which any kind of scalar field can modify the beginning implied by general relativity and big bang models.

Need for the introduction of scalar fields into a cosmic model may not be easy to determine. The telltale clue is this: one or more constants (such as the velocity of light, the electromagnetic and gravitational force constants, or the fine structure constants) took on different values in the distant past. Likewise, the recently proposed "cosmic quintessence," discussed in a previous *Facts for Faith* article, represents an appeal to a cosmic scalar field.[30]

A tightening of the constraints on all such proposals comes from several sources, including physics laboratory experiments, studies of seismic activity on the sun, and new measurements of distant galaxies. For readers who want some details, the following list cites a sampling of the research: the Global Oscillation Network Group (GONG) and the Birmingham Solar Oscillation Network (BiSON) have established that the gravitation constant, G, varies by no more than one part in a trillion per year.[31] Studies of the motions of small-mass galaxies indicate no significant modification of local gravity relative to global gravity.[32] High-resolution spectra of quasars limit the variability of the proton-to-electron mass ratio at less than one part in one hundred trillion per year.[33] The electromagnetic fine structure constant (and consequently the velocity of light and the value of the electron charge), according to recent laboratory experiments and measures of star formation rates in distant galaxies, has varied by no more than one part in a hundred thousand through the billions of years since galaxies first formed (about 13.5 to 14.0 billion years ago).[34] Since star formation in galaxies peaked (roughly seven to ten billion years ago), no room exists for variations in the electromagnetic fine structure.[35]

In other words, the constants remain constant throughout the physically measurable history of the universe. An apparent loophole remains, however, since current research cannot measure cosmic physical conditions any earlier than 10^{-19} seconds after the cosmic creation event (when the universe was a mere one ten-millionth of a trillionth of a second old). Speculations about alternate physics during this miniscule moment continue, and these will be addressed in later paragraphs.

Weird Scalar Fields

In a work just submitted for publication, two cosmologists from Tufts University demonstrated that a universe containing "non-minimally coupled" scalar fields possibly can be free of a cosmic singularity, that is, such a universe may manifest no beginning at all.[36] However, the avoidance of a cosmic beginning produces violations of the second law of thermodynamics (the law of increasing entropy or increasing disorder) over long time periods. Ordinary scalar fields, that is "minimally coupled" scalar fields, do not produce such violations of the second law of thermodynamics.

The possibility of violations of the second law of thermodynamics would place much, if not most, of particle physics, black hole physics, and quantum mechanics in jeopardy. Hence, proposing "non-minimally coupled" scalar fields for the universe must be judged unreasonable. Without getting into all the technical differences between minimally coupled and non-minimally coupled scalar fields, one should note that only certain kinds of non-minimally coupled scalar fields would allow for the possibility of an escape from the singularity. Therefore, any reasonable or observationally possible cosmic scalar field leaves the singularity theorems unchallenged. The universe must have been caused by an *Entity* who transcends matter, energy, and all the space-time dimensions that can be associated with matter and energy.

Quasi-Steady-State Cosmology

Once upon a time, steady-state models of the universe hypothesized an expanding, continuously matter-generating cosmos that forever self-maintains its constant density (Figure 4). The "beginning" of such a universe, if there was one, lies so far back in the infinite past that it ceases to hold any theological significance. However, steady-state models (which constitute a category of scalar field theory) were resoundingly ruled out, even in the opinion of steady-state proponents, by observational evidences many years ago.[37-39] Rather than concede a cosmic beginning in finite time, though, steady-state advocates returned to the drawing board. The new rendition they have developed is called the "quasi-steady-state." Rather than suggesting that matter comes into existence continuously from everywhere in the universe, the customized model proposes that new matter sporadically arises in the nuclei of large active galaxies (galaxies with explosive events occurring in their cores).[40]

The big bang's single primordial fireball is replaced in this new version of steady-state theory by numerous, time-separated fireballs, self-generated matter formed within and ejected from the centers of large galaxies. The nuclei of large galaxies could be described, then, as black holes in reverse. Instead of sucking in matter and energy, these nuclei produce and spew out matter as a result of some hidden creative mechanism. Quasi-steady-state models propose a dramatic reinterpretation of the astronomical bodies known as quasars. These distant super-energetic galaxies are considered by quasi-steady-state theorists to be nearby hot spots ejected from large galaxies.

At first glance, this view seems to have some merit. After all, many quasar images do indeed appear adjacent to galaxy images. A second and deeper look, however, erases that merit. The apparent proximity proves merely an artifact of the observer's crowded field of view (Figure 5). (Sometimes Regulus, the brightest star in Leo, appears very close to the Moon, but its proximity is mere appearance, not reality.)

With the advent of telescopes as powerful as the 400-inch Keck, astronomers have been able to detect faint wisps of galaxy parts enveloping the quasars (Figures 6 and 7). This finding matches what a big bang universe would suggest. Apparently, quasars are not just very bright points of light. They are the nuclei of enormous galaxies in the galaxies' early, formative stage.

An unanswered question about quasars' fuel source also helped the initial plausibility of quasi-steady-state theory. Some quasars burn with such intensity that even the enormous gas supply of supergiant galaxies cannot account for their power output. Until this question could be answered, science left at least a little room for redefining quasars to fit quasi-steady-state scenarios.

Recent Hubble Space Telescope images fill the information gap, however. Just as big bang theorists proposed, the Hubble shows that young supergiant galaxies steal enough gas from nearby galaxies to account for quasars' high power output (Figures 8 and 9). Figure 10 shows one large galaxy merging with a supergiant galaxy at about a million miles per hour. The resulting tidal forces provide the gas needed to fuel the quasar in the nucleus of the supergiant.[41]

In a quasi-steady-state universe, one would expect to observe all manner of astronomical bodies at all distances from any given vantage point, and the density of objects should be roughly the same at all distances. In a big bang universe, on the other hand, one would expect to see different objects in different proximity to each other at different distances. Again, the Hubble Space Telescope provides helpful data.[42, 43] It shows that at great distances from Earth all the galaxies are young galaxies, and all these young galaxies are packed tightly together

(Figure 11). At relatively close distances, all, or nearly all, the galaxies are middle-aged, and they are relatively spread out from one another (Figure 12). This picture of galaxies looking younger and younger and more and more crowded together the farther away one looks contradicts the predictions of the quasi-steady-state model but is exactly what one would expect in an expanding big bang universe. (Since distance corresponds to light-travel time, similar distance means similar age.)

In a big bang universe, quasars would be most abundant when their fuel supply was most abundant. Therefore, astronomers would expect no quasars to exist in the recent or current era, that is, at distances corresponding to short light-travel times. Not enough gas remains to provide for their enormous fuel requirements. At distances corresponding to about half the age of the universe, quasars should be rare, again because of the diminishing fuel supply. At distances equivalent to about a fifth the age of the universe, they should be abundant because that is when fuel was abundantly available. At distances equivalent to about a tenth the age of the universe they should be rare, for at that stage in cosmic history, the number of condensed gas clouds could sustain no more than a few quasars. Reliable space density surveys of quasars, first published in the mid 1990s, confirmed these big bang predictions while contradicting the quasi-steady-state predictions.[44-50]

According to the big bang model, quasars require extremely large fuel supplies—so large, in fact, that quasar life spans must be relatively brief, between a million years and a hundred million years. A recent study done by Princeton University astronomers exploits deep sky surveys to measure quasar clustering, which in turn allows for calculation of the average quasar life span. This calculation proves consistent with the big bang projections.[51]

More recent observations continue to argue for the big bang models and against the quasi-steady-state.[52] The latest findings confirm that supermassive, supercondensed bodies, that is, black holes, do exist in the cores of giant galaxies, not the reverse of black holes proposed by the quasi-steady-state. Researchers found a way to measure the spin velocities in the inner regions surrounding such supercondensed bodies. These velocities measured close to one-third the velocity of light, a result that can only be explained if the supercondensed bodies are black holes exceeding a million solar masses.[53]

Quasi-steady-state proponents assert that the shifting of the spectral lines of quasars toward longer, or "redder," wavelengths may not necessarily place the quasars at great distances. High velocities indicated by the redshifts could result, they say, from the quasars' high-speed ejection from galactic nuclei. A direct refutation of this point seemed impossible at first, since the distances proposed by big bang models for quasars lie beyond the reach of all measuring methods except the shifting of spectral lines.

This impasse on distance measures was broken in June 2000. At radio wavelengths, distantly separated telescopes can be linked together to create an instrument with the equivalent resolving power of a 6,000-mile diameter telescope.[54] Making use of such an instrument, a team of American astronomers achieved a direct distance measurement (based on the trigonometric method familiar to land surveyors).[55] They determined that Quasar 3C 279 must be at least 5.9 billion light years away. This trigonometric distance measurement matches the big bang redshift distance measurement.

In the quasi-steady-state model all the helium in the universe comes from nuclear burning that takes place inside stars. To account for all the helium astronomers see, stars in the quasi-steady-state model must have been burning for at least a hundred billion years. Astronomers fail to see any stars or galaxies anywhere in the universe older than 14 billion years. Moreover, while stars are efficient in distributing elements heavier than helium throughout space (via explosions), most of the helium produced by stars remains trapped inside dead stars. The ratio of heavy elements to helium in both the interstellar medium and intergalactic medium is consistent with big bang predictions. That same ratio contradicts the quasi-steady-state model.

As refutations of the quasi-steady-state model accumulate, so does corroborating evidence for a big bang expanding universe. The density of baryons (protons plus neutrons) in the universe,[56-60] the density of exotic matter in the universe,[61-65] and the characteristics of the cosmic background radiation[66, 67] all argue in favor of the big bang and against quasi-steady-state. Unfortunately, many of these findings came together *after* publication of a book by the three major proponents of the quasi-steady-state model, Sir Fred Hoyle, Geoffrey Burbidge, and Jayant Narlikar.[68]

A form of the steady-state model still seriously entertained by astronomers has been dubbed the “eternal inflation” model. In this scenario, the continual, spontaneous generation of entire universes supplants the old steady-state’s continual self-generation of protons and neutrons. According to this newer version of the steady-state, universes spontaneously appear as expanding bubbles in an infinite, eternal, quantum-fluctuating, space-time foam. This model belongs to the larger category of multiple universe models, most of which can neither be verified nor falsified and, thus, belong to the realm of metaphysics. (See sidebar entitled “An Infinity of Universes?”)

Layman’s Guide to Alternate Cosmologies

No matter how tightly observations constrain the characteristics of the universe, alternative cosmologies will always exist. The nature of science predicts it, and so does human nature. Some people cling to their nonscientific rationale for rejecting big bang cosmology; others cling to theologically unsound reasons for rejecting its parallel in biblical cosmology. At some point, however, the veil of rationality wears noticeably thin.

Sorting through these scientifically technical models may seem daunting to a layperson, but it need not send him or her running. Certain questions can help anyone, scientist or otherwise, to ascertain the merits of an idea about cosmic origins:

Has the physical evidence for a certain model grown stronger or weaker, relative to that for other origins models, through the past year, five years, decade, or more?

Is the model gaining or losing advocates among the research experts?

Is the model based upon proven, or at least testable, mechanisms?

Does the model appeal to physics (that which humans have the potential to detect and measure) or to metaphysics (which humans have no potential to detect or measure) for its support?

Does the model rely on a supposed, rather than observed, violation of established physical laws? A basic, elementary-level textbook can provide a helpful review of those laws.

One can apply these questions to the now popular appeal to a quantum mechanical space-time foam as a source of an infinite or near infinite number of universes. This appeal violates the laws of quantum mechanics. One law of quantum mechanics states that the smaller the time interval, the smaller the probability for a quantum event. At the moment of creation, the universe’s time interval is zero. (Time is created at the creation event.) With a zero time interval, the probability for a universe to pop into existence through some kind of quantum event would equal zero. Another quantum mechanical law stipulates that the bigger the mass brought into existence through a quantum fluctuation in the space-time fabric, the faster that mass must be returned to the space-time continuum. For something as massive as our observable universe, the return time would be briefer than 10^{-120} seconds. No one argues that the universe is so young.

Could quantum mechanical laws have been different when the universe was younger than 10^{-34} seconds old? The answer, of course, is yes, it is possible. However, one must consider the remoteness of that possibility. Astrophysicists can point to no evidence for different quantum mechanical laws during the first trillionth of a trillionth of a trillionth of a second of the universe’s history. Given that physicists know the quantum mechanical laws hold for 99.99999999999999999999999999999999999999999999999 percent of the universe’s history, one should demand at least some physical evidence before conceding that different quantum mechanical laws operated previously. One problem thought to require alternate physical laws for its solution has been solved without such an appeal: the seeming incompatibility of gravity and quantum mechanics during the first split second of cosmic history. Ten-dimensional string theory provided the explanation. It demonstrates that gravity and quantum mechanics can successfully coexist, given ten space-time dimensions, all the way back to the cosmic creation event, to that moment when time begins.[69]

Pursuit of truth is, and must remain, the driving force behind scientific endeavor. As long as it remains so, Christians can enthusiastically celebrate science. Christians can be the best of scientists, for their confidence in the Source of truth gives them the freedom to embrace whatever facts their study of the natural realm reveals.

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