Does the Big Bang Demystify Creation in the Finite Past?

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Abstract

Is the doctrine of creation *ex nihilo* in the finite past knowable apart from revelation, or is it a mystery? Some have claimed that the Big Bang cosmological singularity provides strong evidence for creation in the finite past, and thus for creation and theism, but there are several good reasons for rejecting this claim. First, the *a priori* Leibnizian intuition that the world is like a watch and God is not an incompetent watchmaker, conjoined with the *a posteriori* recognition of time reversal invariant physics, implies that God would not have created a world that would break down as the physical laws are mathematically run backward in time. This intuition plays a constructive role in physics. Second, the typical reasoning using general relativistic singularity theorems, upon time reversal, leads to absurdity: the Big Bang singularity supports creation *ex nihilo* only if the gravitational collapse of stars implies that God miraculously annihilates the interior singularity of the black hole at the end point of stellar gravitational collapse. Third, the generic underdetermination of theories by data gives reason for much caution in making the *infinite extrapolation* made in trusting the equations of general relativity all the way to the singularities. Given the classical physical theories on hand (to say nothing of theories never yet proposed), it is unclear that the Big Bang singularity is a warranted scientific inference. Finally, the lessons from quantum physics applied to nongravitational theories provides reason to expect that quantum gravitational effects are strong in the early ultra-hot ultra-dense phase of the universe allegedly preceded by the singularity, so there is no good reason to think that classical general relativity is a trustworthy guide in such contexts. The argument also has methodological shortcomings. The failure of the Big Bang argument to demonstrate creation in time poses little difficulty for affirming the doctrine by faith, in line with Aquinas.

1 The Doctrine of Creation in Time and Its Warrant

To discuss whether Big Bang cosmology strongly confirms creation in time or not, it is helpful to have a rough idea of the doctrine. I take the essential claim of creation *ex nihilo* to be that God brings all other things into existence voluntarily and without using pre-existing materials. Given creation *ex nihilo*, a secondary question is whether God created the world in the finite past or eternally. We may speak of "eternal creation" if the universe is infinitely old, or "creation in time" if the universe is finitely old and had a first moment of existence. If the universe is finitely old but had no first moment, then it is unclear whether creation in time or eternal creation is a more appropriate term, especially on account of conventionality worries to be discussed below. Clearly creation in time entails creation *ex nihilo*, which in turn entails theism. If there were a good argument for creation in time from Big Bang cosmology or other sources besides Scripture, such an argument would be dialectically helpful.

Advocates of creation in time have disagreed whether the finite age of the universe could be known by reason or only by faith [1]. In response to Aristotelian philosophical arguments for an *eternal* universe, Moses Maimonides and Thomas Aquinas both held such arguments to be inconclusive. Both also held philosophical arguments—or at least the ones of their days—for a universe of finite age to be inconclusive, leaving the issue to settled in favor of finitude by Scripture [2]. Given the role of Scripture in the development of the doctrine of creation and indeed in Christian theology generally, agreement with Scripture certainly is desirable. Creation in time is preferable on Scriptural and traditional grounds, as even Aquinas and Maimonides held. If the doctrine of creation does not absolutely require a first moment or even a finite age, still the advantages over an eternal universe are not negligible. Thus Paul Helm is overly hasty in endorsing [3] John Polkinghorne's claim that "[t]heology is concerned with ontological origin and not with temporal beginning. The idea of creation has no special stake in a datable start to the universe." [4] If modern science and medieval Aristotelian philosophy are included within a broadly construed reason, then those who claim that Big Bang cosmology supports creation in time follow Bonaventure in spirit. More in line with Maimonides and Aquinas, I take it that the universe is finitely old and likely has a first moment, but this conclusion is based on special revelation rather than on unaided reason. One should note that whether Scripture in fact teaches creation in time has become controversial. William Lane Craig defends creation in time as the Biblical view [5, 6] and refers to the work of others.

The epistemology of creation, at least for the author of Hebrews, might tend to favor Aquinas rather than Bonaventure. The key passage is Hebrews 11:3: “By faith we understand that the worlds were prepared by the word of God, so that what is seen was not made out of things which are visible.” (NASB) Hebrews 11 gives a long list of commendable beliefs held and actions performed by God’s people on the basis of faith in divine revelation and activity, rather than induction on experience. For the author of Hebrews and his audience, the doctrine of creation was known by faith in special revelation, not by rational demonstration or empirical observation. Have matters improved for us? A successful argument for creation apart from special revelation would be useful. In various works William Lane Craig, developing the medieval *kalam* tradition, offers an *a priori* argument for creation in time [7]. Some have objected to the treatment of infinity in such works [8]. If creation in time could be known *a priori*, then arguments from physical cosmology would be largely redundant. For the sake of argument I therefore assume that a finite past is metaphysically possible. Big Bang cosmology is sometimes invoked to show *a posteriori* that, at least in worlds physically similar to the actual world (in both regularities and physical state), the universe is finitely old and had a beginning. Here I will argue that the Big Bang cosmological singularity provides no good argument for a beginning of the universe. Given that Hebrews 11:3 takes knowledge of creation to be had “by faith,” we need not be distraught if such arguments fail; perhaps we should be surprised if they succeeded.

If a universe is a created one, is it eternal, finitely old but lacking a first moment, or finitely old with a first moment? Presumably time is isomorphic to the real numbers, the integers, or a connected subset (having no holes in the middle, so to speak) of either. Thus the universe’s having a first moment entails its being finitely old, but the converse entailment might fail. If time is continuous, then the world’s being finitely old does not entail its having a first moment. At least *prima facie* it seems that a universe with a first moment is the sort most confirmatory of theism, while an eternal universe is the least helpful. At least regarding the two extreme cases, Aquinas held something along these lines, as Ernan McMullin discusses:

> If the universe began at a point of time, would this give stronger support to the claim that a Creator is needed than if the universe always existed? Aquinas argued that in a sense it would, even though he was insistent that a universe which had always existed *would* equally need a Creator to sustain it. But creation in time rather than from eternity makes the work of God’s power more evident, Aquinas says, because an

> agent displays the more power in acting, the more removed from act is the potency acted upon. And in creation in time there is no potency of any kind to work on. This of itself immediately shows the infinity of power required to summon a universe into act. [9, p. 39]

A first moment appears to convey two advantages on the doctrine of creation over mere finite age. First, it is more obvious that a finitely old universe with a first moment requires an external Cause than that a finitely old universe in which every moment is preceded by an earlier one does. In the latter case, one might be tempted to think that the present is fully explained by the past within the history of the universe, so nothing external is required [10]. Second, having a first moment is a topological notion, not a metrical one, and so escapes conventionality worries [9–13] about temporal remetrization of a finite past to an infinite one and the conventionality of the metric [14]. Metrical conventionality becomes an especially serious worry in physical theories containing multiple metrics. Scalar-tensor theories are perhaps the best known locus for the question "Which metric is the physical metric?" [15, 16] While this question seems not to need an answer for most purposes (such as those involving only the field equations), questions of singularities, boundary conditions and positive energy give that question a bit more urgency [17, 18]. Theories with multiple metrics might have different types of matter coupling to gravity in different ways; then some metrics might yield finite age and some infinite, in which case there seems to be no answer to the question "how old is the universe?" even if options at hand are merely "finite" and "infinite." It turns out that the actual universe probably is not of that sort, given the empirical confirmation of the various principles of equivalence in gravity [19]. But a doctrine of creation needs to be modally rich enough to consider even possible worlds in which God does not create, as well as all worlds in which God creates. It is dissatisfying to have a criterion for creation in time that probably can be applied in the actual world, but fails in many possible worlds where God creates a world with somewhat different laws or regularities. Conventionalist questions about the significance of the difference finite *vs.* infinite seem to be due to Milne [9, 20, p. 209]. As it turns out, the Fourth Lateran Council in 1215 made it a doctrine of faith for Roman Catholics that the world had a temporal beginning, and even escapes the conventionalist worry by positing a first moment [9].

2 Modern Cosmology and Creation

Modern physical cosmology is a rather effective framework for unifying and explaining a wide variety of astronomical observations in a framework provided by well-confirmed physical laws that hold here and now. Roughly speaking, one assumes a Robertson-Walker spacetime metric satisfying Einstein's gravitational field equations. This metric is spatially homogeneous and isotropic, meaning that every point in space is alike at a given moment of time, and every direction is also. Clearly this is an idealization. Data from the present, especially the fact that luminous objects' redshifts are larger for more distant objects, indicate that the universe is expanding (*modulo* conventional redescription). The dynamics of general relativity, with standard kinds of matter, lets one extrapolate back to an earlier hot dense phase, during which time plausibly the observed cosmic abundances of light elements were produced. Mathematical extrapolation still further into the past—a bold move that might have little warrant—implies that the spacetime metric was singular roughly 14,000,000,000 years ago: there was a state of infinite curvature and density, through which Einstein's equations allow no further retrodiction. Contrary to some earlier hopes still present in the 1960s, general relativistic singularity theorems show the singular behavior to be generic, not an artifact of the high symmetry assumed in homogeneous isotropic or spherically symmetric models as it is in Newtonian gravity [21]. If homogeneity is assumed (as it usually is, at least for the prototypical models such as Robertson-Walker), then the singularity occurs everywhere throughout all space, so it has seemed natural to speak of an origin of space (or space-time) at the singularity. However, homogeneity on scales beyond the horizon is an assumption or convention [22, 23], not an empirical fact. Indeed even the global topology of space-time is subject to worries regarding conventionality [24, 25]. Empirically we have no access to regions more distant than some billions of light years (at least apart from quantum mechanics), due to relativistic causality constraints, so claims that homogeneity holds out to, say, a trillion light-years, or 10^{30} light-years, are not observationally well grounded. A bit of historical perspective is useful here. Though there were exceptions, "[i]n the ideological debate of the late 19th century, finitism—the view that the world is finite in time and space—was usually associated with conservativism and Christian belief, whereas socialists and materialists adhered to the doctrine of an infinite and eternal universe." [20, p. 57]

Some authors present the Big Bang singularity as potent evidence for the Christian doctrine of creation *ex nihilo* and consequently for theism. Among the most visible proponents at present are philosopher-theologian William Lane Craig [26] and astrophysicist-apologist Hugh Ross [27, 28], though noteworthy working physicists and astronomers and at least one pope [9, 20], Pius XII, also have endorsed it. Ross goes so far as to say that "[t]he space-time theorem of general relativity leads not just to a theistic conclusions but specifically to the God of the Bible." [27, p. 71] There is anecdotal evidence that the argument serves as a persuasive apologetic and evangelistic tool, if Ross's claims elsewhere are an indication. While dialectically effective arguments for theism are valuable, one should not use bad arguments for theism even if they are persuasive. As will appear, the Big Bang argument is logically a bad argument for theism. This argument been criticized by others, such as Craig's coauthor Quentin Smith [26] and Adolf Grünbaum [29], but on somewhat different, and perhaps not always compelling, grounds.

Craig formulates an argument along these lines:

1. "Everything that begins to exist has a cause of its existence.
2. The universe began to exist.
3. Therefore the universe has a cause of its existence." [7, p. 63]

This argument is valid. The first premise seems true. So does the second, at least to me, but on what grounds? Does Big Bang cosmology provide good reason to believe the second premise? I will argue that it does not.

The question thus arises whether one ought to take seriously the Big Bang singularity as a feature of the world, in the sense that the singular Robertson-Walker metric tells an approximately true story in the neighborhood of, and perhaps at, the singularity. The singularity itself is physically meaningless, because it involves an infinite value for certain physical quantities. Should one trust the Big Bang model *near* the singularity? If so, then the worry that the universe is self-sufficient because every event is preceded by an earlier one, as well as the conventionalist worry that there exists no sharp distinction between an eternal world and one with no first moment, become relevant. Such issues have featured in a long but not always fruitful exchange between Craig and Grünbaum. It is most reasonable, I will argue, to dismiss the physical behavior in the neighborhood of the singularity as a mathematical artifact of our incomplete physical understanding embodied in an excellent but nonetheless flawed physical theory. This view is largely taken for granted among workers in quantum gravity and was defended worthily in the context of the theological relevance of the Big Bang by Jayant Narlikar [30].

There are several good reasons for rejecting the Big Bang singularity as the basis for an argument for creation in time. First, the *a priori* Leibnizian intuition that the world is like a watch and God is not an incompetent watchmaker, conjoined with time reversal invariant physics, implies that God would not have created a world that would break down as the physical laws are mathematically run backward in time. This intuition plays a constructive role in physical theory construction and selection, so it cannot be rejected flatly without threatening serious harm to the practice of physics. Second and somewhat more *a posteriori*, the typical reasoning using general relativistic singularity theorems, upon time reversal, demonstrates that the Big Bang singularity supports creation *ex nihilo* only if the gravitational collapse of stars implies that God miraculously annihilates the interior singularity of the black hole at the end point of stellar gravitational collapse. But gravitational collapse of stars is hardly a fitting occasion for special divine action (SDA). Third, the generic underdetermination of theories by data gives reason for much caution in making the *infinite extrapolation* in energy scale made in trusting the equations of general relativity all the way to the singularities. Given the physical theories on hand (to say nothing of theories never yet proposed), it is unclear that the Big Bang singularity is a warranted scientific inference. Finally, the lessons from quantum physics applied to nongravitational theories provides reason to expect that quantum gravitational effects are strong in the early ultra-hot ultra-dense phase of the universe allegedly preceded by the singularity, so there is good reason to doubt that classical general relativity is a trustworthy guide in such contexts. There are also methodological problems.

One might notice that I have neglected thermodynamical arguments [20, 27] that might bolster the singularity's physical status. This neglect of mine seems justified by two factors, one conceptual and enduring and one temporary and technical. The enduring conceptual problem is that thermodynamics is not a fundamental physical theory, but rather arises (allegedly) as a limit from statistical mechanics. Famously it is unclear just precisely how thermodynamics follows from statistical mechanics; indeed famous paradoxes have existed for roughly a century. More importantly, thermodynamical claims of increasing entropy and the like probably are unreliable in the absence of an adequate treatment of the thermodynamics of *gravitation itself.* Gravitation has a long range and cannot be screened, in contrast to typical textbook thermodynamics systems, so many standard features of thermodynamics (such as positive specific heats, spatial homogeneity of systems of in equilibrium, and the proportionality of entropy to volume) can fail for gravitation [31–33]. Recently progress on gravitational thermodynamics has been made; reassuringly, black hole thermodynamics (with entropy proportional to area) and standard thermodynamics both obtain in appropriate limits [31]. Perhaps eventually a good thermodynamic argument will be available for theistic purposes, but such a new argument will look rather different from arguments that have been used in the past. It might look more like a teleological argument rather than a cosmological argument in the philosopher's sense.

3 Leibniz against Incompetent Watchmaker God

In the Leibniz-Clarke correspondence [34, pp. 11. 12], Leibniz famously argued against Isaac Newton and Samuel Clarke that God would not create the physical universe in such a way that it would break down and require repair from time to time. Leibniz took Newton's views to have just such a consequence, so if the world is analogous to a watch, then Newton's God is an incompetent watchmaker because Newton's God was required to perform miracles to restore the solar system to working order. Whether Newton and Clarke deserved this criticism need not concern us. One might worry that to liken the universe to a watch is to make an unargued *normative* claim that God ought not to perform miracles, which argument could easily lead toward deism. However, the valuable part of Leibniz's intuition can be separated from such worrisome tendencies. Leibniz accepted miracles of grace, while rejecting miracles posited to fix nature due to poor design [34, p. 12]. Such a distinction is parallel to one made in the Westminster Confession of Faith (1646-7):

> God, in His ordinary providence, maketh use of means, yet is free to work without, above, and against them, at His pleasure. (ch. 5, sect. 3)

God's use of means in his ordinary providence suggests a certain internal integrity to ordinary providence, such that God need not employ special providence simply to correct mistakes made in ordinary providence, though God remains free to engage in special providence as suits the occasion. The Westminster Confession reminds us that the orthodox view has included both general and special providence and has not been biased heavily against the latter. Leibniz's watch metaphor had no inevitable deistic tendency in the context of his monadology, where the several monads act in a pre-established harmony with "miracles" built-in as much as more ordinary behavior is. Leibniz's monads are importantly unlike watches.

Even if Leibniz is partly to blame for furthering deistic tendencies, I invoke a much weaker standard of design that has no such problem. Much depends on what counts as a "broken" world. It is logically impossible for something to break if it has no sense of proper function or design. Evidently what Leibniz finds objectionable in Newton's work is the conjunction of the claim that the solar system is divinely designed to behave in a certain orderly way, with the claim that it will do so only for a finite amount of time without divine rejuvenation [34, pp. 11, 12, 180]. For Leibniz, God is a perfect designer who would build the solar system as a perpetual motion machine. He also seems to believe that the conservation of *vis viva* guarantees as much. Thus Leibniz's *a priori* "God wouldn't do it that way" claim sets high teleological standards for the Deity's work. One could imagine Leibniz's being content with the claim that this world has a *whole* was the best possible, but here he seems to expect the best possible design for a specific part of the world. That the God of Job seeks to meet this Leibnizian standard of perfect design is unclear, given God's contented description of the imprudence of mother ostriches in Job 39:14-17, for example [35, p. 178]. A solar system that disintegrates with pieces flying in every direction is still a physical system behaving in accord with physical laws. By contrast, a universe or portion thereof that evolves from a normal into a singular state in a finite time violates even a very low standard of design.

At this point the time reversal invariance of modern physics becomes relevant. Maxwell's electromagnetism [36] and Einstein's theory of gravity [21] are both invariant under time reversal, which is to say that the laws run backward mathematically in just the same way and with the same ease as they run forward in time. For any solution of the equations, there is a corresponding one differing only in having the opposite sense of time. If one includes more general fields, then time reversal invariance (often called T invariance), strictly speaking, fails to hold, but a generalization remains. While not proven with logical certainty, the generalized time reversal invariance of fundamental laws seems demonstrated beyond a reasonable doubt. Even if it fails eventually, it holds for the physics employed by proponents of the Big Bang argument for creation in time.

Combining the Leibnizian intuition about divine workmanship and ordinary providence with time reversal invariance implies that, just as God would not build a machine that breaks and requires repair in the future, neither would he build a machine *incapable of having run forever.* Put differently, God's ordinary providence would not be described by mathematical equations which retrodict their own breakdown in the finite past. But the Big Bang singularity is just such a retrodicted breakdown in the finite past using Einstein's gravitational field equations for laws. Thus Einstein's equations, though simple, empirically adequate, fruitful, in some sense beautiful, and approximately true, are nonetheless false. This is hardly a controversial conclusion. Surely a quantum theory of gravity is needed, so classical gravity is false, though usually a good approximation. But if General Relativity is false, then why trust it far beyond its tested regime of validity when its results seem unphysical, as proponents of the Big Bang argument do? Far from being a theistic proof, the Big Bang serves rather as a *reductio ad absurdum* of Einstein's field equations for gravity and a motivation for quantum gravity. The Big Bang argument can be retained only at the cost of rejecting the desirable core of the Leibnizian intuition about divine workmanship or by setting aside the consensus view of physicists in favor of time reversal invariance of physical laws, not to mention Einstein's theory of gravity.

4 Role of Leibnizian Intuition in Physics

The time reversal invariance of physical laws seeming rather secure, the proponent of the Big Bang argument for theism might be tempted to reject the Leibnizian intuition. Rejecting the intuition would be unwise because, if pursued in a logically consistent way, it would threaten physical research by depriving physicists of an important test for reducing some false theories to absurdity. An historical parallel comes to mind. The story of blackbody radiation and the development of quantum theory is complicated [37], much more so than the view given in modern physics textbooks, but the following selection should suffice. Just under a century ago, there were good classical theoretical arguments for the Rayleigh-Jeans law for blackbody radiation, according to which the energy density for radiation at a given frequency increased with frequency. (The Rayleigh-Jeans law was also demonstrably false empirically, but in some ways that is an irrelevant accident for present purposes.) But such a radiation law has to be wrong, because integrating over all frequencies (up to $+\infty$) implies that a blackbody radiates *infinite* power. Ordinary objects, especially black ones, approximate blackbodies, so they would radiate away their energy immediately in a blinding flash, contrary to experience. This difficulty has come to be known as the "ultraviolet catastrophe." The answer of Planck and others to the threatening inference of ultraviolet catastrophe, history shows, helped to lead to quantum mechanics. New theoretical foundations were brought in that yielded an exponentially decaying factor to counteract the Rayleigh-Jeans power law growth and thus give a convergent integral up to infinite frequency. (The exponentially decaying factor preceded widespread worries about the ultraviolet catastrophe, but previously it was motivated on more empirical grounds.) From a logical point of view, the ultraviolet catastrophe was a *reductio ad absurdum* classical physics underlying the Rayleigh-Jeans radiation law. The solution was new physics of a quantum kind, which averted the catastrophic infinity. Clearly the moment-by-moment absence of such a disaster falls under the category of general providence. In theological terms, a flaw in our understanding of general providence was resolved not by special providence, but by an improved understanding of general providence.

A crude analog of the Big Bang argument might be something like the following: established physical laws show that objects ought to radiate vast amounts of energy in a blinding flash of high frequency ("ultraviolet") radiation, destroying the world as we know it; but no such phenomenon occurs; so some preternatural phenomenon must be counteracting the natural tendency toward ultraviolet catastrophe. This argument is sketched not because anyone defends it, but because it has a similar flavor to the Big Bang argument, while being plainly unpersuasive. The challenge for the Big Bang arguer is to show why this ultraviolet catastrophe argument should not be made, while the Big Bang argument should be made. As will appear below, a further difficulty is that Einstein's theory of gravity implies that ordinary matter, such as stars, produces infinite gravitational curvature in finite time (according to standard general relativity), which seems disastrous in much the way that the ultraviolet catastrophe would be. How is one to distinguish the singularities in our physical laws that imply SDA from those that imply ignorance of physics, that is, of God's methods of ordinary providence?

One common standard for a good physical theory is that it not break down, such as by implying a 'state' of infinite density and temperature, or a discontinuous jump in physical quantities, or the like–physical singularities, in short. Thus, if a given theory implies such indignities, then physicists will tend to look for an improved one that does not. It has long been hoped that singularities would be avoided when gravity and quantum mechanics are finally united, much as the problem of unstable atoms in classical electromagnetism was solved by uniting electromagnetism with quantum mechanics. Such hopes are routinely expressed in the literature on quantum gravity. Indeed resolution of singularities—not only cosmological singularities, but also those due to gravitational collapse—is one of the main motivations for working on quantum gravity. Certainly applications or even easy experimental tests do not encourage the work! Thus Abhay Ashtekar, one of the dominant figures in contemporary work on quantum gravity, opened a recent review of the field with the following motivation:

> *Big-Bang and other singularities:* It is widely believed that the prediction of a singularity, such as the big-bang of classical general relativity, is primarily a signal that the theory has been pushed beyond the domain of its validity. A key question to any quantum gravity theory, then, is: What replaces the big-bang? Qualitatively, classical geometry may be a mean field like 'magnetization', which provides an excellent macroscopic description of a ferromagnet. However, at the Curie temperature, magnetization goes to zero and susceptibility diverges. But there is no physical infinity; we simply have to turn to the correct *microscopic* description in terms of spin-systems to describe physics. Does something similar happen at the big-bang and other singularities? Is there a mathematically consistent description of the quantum state of the universe which replaces the classical big-bang? What is the analog of the microscopic spin-system that underlies magnetism? What can we say about the 'initial conditions', i.e., the quantum state of geometry and matter that correctly describes the big-bang? If they have to be imposed externally, is there a *physical* guiding principle? [38]

One can find similar sentiments elsewhere among workers in quantum gravity.

A noteworthy step towards vindicating this hope appeared recently in Martin Bojowald's succession of papers on loop quantum cosmology, a project of investigation homogeneous (hence "cosmological") solutions of the modern nonperturbative canonical quantum gravity project. Modern canonical quantum gravity [39] began in the 1980s when Abhay Ashtekar proposed new variables that helped to resolve long-standing problems faced using the older metric variables. In this tradition, Bojowald's "Absence of Singularity in Loop Quantum Cosmology" [40] shows that "the cosmological singularity in isotropic minisuperspaces is naturally removed by quantum geometry." Bojowald's efforts have continued to bear fruit in successor papers [41–43]. The significance of Bojowald's work lies especially in its being deeply rooted in a detailed natural and at least moderately successful (to date) project of quantizing gravity using first principles (but see ([44]).

5 Absurd Stellar Collapse Analog of Big Bang Argument

Above it was asked why proponents of the Big Bang argument ascribe theological significance to the Big Bang singularity, but not to other physical singularities. This worry takes its most acute form when one considers the similarity of the Big Bang cosmology to the time reverse of the gravitational collapse of a star to a black hole with a central singularity. The worry is this: if the Big Bang strongly indicates that there exists a God who created the universe, do formally similar time-reversed events such as the gravitational collapse of stars to form black holes with singularities imply that there exists a God who supernaturally destroys (annihilates, ceases to uphold) the interior of stars? It seems ludicrous to draw such a conclusion. At the very least one would want to try a good theory of quantum gravity before drawing such a conclusion. But such a conclusion, silly as it may be, is difficult to avoid if one takes the Big Bang to be good evidence for a Creator. Ross's frequent discussion of gravitational singularity theorems [27] makes it the more surprising that the consequences of the parallel between the Big Bang and gravitational collapse have not been discussed more fully.

One tempting reply might be that the Big Bang singularity is distinguished from gravitational collapse singularities in black holes by the spatial omnipresence of the Big Bang singularity, in contrast to the localized black hole singularity. This attempted distinction, however, fails because it relies crucially on an inessential, conventional and dialectically somewhat implausible feature of the usual cosmological models. As the reader will recall [22, 23] and as is explained patiently by Samuel Conner and the eminent Donald Page in a different polemical context [45], one can easily modify the homogeneous hot big bang by dropping homogeneity in favor of local homogeneity within the horizon. One might picture the matter of the universe as being a giant ball, perhaps a trillion light-years across or larger, in otherwise empty space. Such a move is usually rejected on the basis of some naturalistic argument or other. Two common choices for the naturalistic argument are the idea that the universe ought not to consist of localized matter in an empty void, lest the world run down, and an anti-teleological induction beginning with Copernicus and culminating in Darwin. The logical extreme of de-privileging Earth is to say that everywhere in space is like here. But this anti-teleological induction will hardly impress progressive creationist Christians such as Ross. That the Copernican revolution demoted humanity from some previously privileged position, is, as Dennis Danielson has pointed out, a piece of mythology [46]; the Christianized Aristotelian-Ptolemaic universe put earth at the bottom, in nearly the worst place, just above hell and far below the heavenly realm of unchanging perfection. [1] Some advocates of the Big Bang argument, such as Ross, are progressive creationists and will find an induction terminating in Darwin unpersuasive; others might hold to guided evolutionary stories, in which case again the anti-teleological flavor of Darwinism will not convince. An induction based on a handful of doubtful instances does not make a compelling argument, so one need not be overly worried that giving up homogeneity places Earth in a privileged position (though the privileging of Earth by new standards has recently been argued [47]). Moreover, for a sufficiently large ball of matter, there can be arbitrarily (but finitely) many places just like Earth, giving up homogeneity hardly restores the Ptolemaic-Aristotelian centrality of Earth. Considering that proponents of the Big Bang argument are often hearty theists, they especially ought to doubt the anti-teleological justification for the homogeneity of the universe, so they ought to recognize the conventionality of homogeneity and hence of the spatial omnipresence of the singularity. On the other hand, arguments in favor of God's creating matter throughout infinite space seem unpersuasive or risk proving too much. Does divine infinity suggest that God should fill infinite space with matter? It is not clear why, especially given that God uses the foolish, weak and despised things of the world to shame the wise (I Corinthians 1-3), thereby demonstrating a tendency to frustrate natural human expectations for displays of power.

It follows that the omnipresence of the cosmic singularity is conventional and that this convention has little claim on the acceptance the proponents of the Big Bang argument for creation in time. Thus the distinction between the spatial omnipresence of the Big Bang singularity and spatial localization in stellar gravitational collapse cannot plausibly be invoked to explain why stellar gravitational collapse to a black hole singularity is theologically insignificant while the Big Bang is of great theological import. When one recalls that collapsing stars [48] and bounded universes both involve a Robertson-Walker homogeneous interior matched with a Schwarzschild exterior, the difference being largely a question of size, the difficulty in ascribing theological import to the Big Bang but not gravitational collapse becomes still harder. If the Big Bang

[1] If this "Copernican Cliche" is unpersuasive, still (as Michael J. Crowe pointed out to me in a discussion of Danielson's work) something ought to be said about the vastly increased size of the non-empty universe and the possibility of other inhabited Earths. The Christian doctrine of the Incarnation of God the Son as a man seems awkward if the universe is full of intelligent life on other planets, at least some of which might have fallen into sin, *etc.* Granting that ET made an interesting argument for Deism, it has no bite against teleology.

singularity were *essentially* spatially omnipresent, rather than just a very large or contingently omnipresent example of a phenomenon that also happens in localized and theologically insignificant contexts, then it would be much easier to ascribe theological significance to it.

Let us summarize. Stellar collapse and hot Big Bang cosmology differ in that the latter is usually regarded as filling all of space, which might be infinite in volume, but this difference is merely conventional and not rhetorically effective for many proponents of the Big Bang argument. Once the irrelevance of this difference is conceded, it is still true that stellar collapse occurs on a much smaller distance scale than does Big Bang cosmology. But surely a difference in size alone is of no philosophical significance. Finally, Big Bang cosmology and stellar collapse differ in that the former involves expansion but the latter involves collapse. However, expansion and collapse are identical up to time reversal, while general relativity is time-reversal invariant. Thus there is, apparently, no relevant physical difference between Big Bang cosmology and stellar collapse. Thus there seems to be plausible no way for the Big Bang argument's proponent to avoid the absurd conclusion that stellar gravitational collapse implies the existence of a Deity who supernaturally destroys the black hole singularity that results.

6 Stacking the Deck for General Relativity

There is a misleadingly persuasive move made by proponents of the Big Bang argument. This move has the effect of stacking the deck in favor of general relativity and thus of Big Bang cosmology against nonsingular rivals. The move is generally not made explicitly and in detail, so what follows is a reconstruction of the reasoning process that would underlie any good argument in the vicinity. It is often suggested that potentially nonsingular rivals to general relativity are speculative, whereas general relativity is well confirmed, so general relativity and its retrodiction of the Big Bang singularity ought to be accepted as the default view that challengers need to overcome with better empirical results.

There is a grain of truth in this claim: some or perhaps many of the theories or models actually proposed as rivals to the Big Bang do not form part of a well-tested theory that is known to reproduce the empirical successes of general relativity. Thus some of many of these challengers might be refuted by data already in hand, should someone think to do the necessary calculations and apply the relevant empirical data to the challengers. Such challengers, if not stillborn, at least soon die of birth defects, though it might take a few years for the physics community to realize that because human finitude prevents the community from drawing every conclusion that is logically entailed by what the community knows. Were the physics community's (or its members') knowledge closed under entailment, such would-be challengers would be refuted even before publication. Thus one cannot simply collect some dozens of papers and preprints that discuss nonsingular cosmological models (as I have done) and conclude that there are that many live challengers to Big Bang cosmology at the moment. However, the grain of truth in this objection sometimes conceals the grain of falsehood that it also contains. Though not entirely trivial, it is possible to construct theories that reproduce the empirical successes of general relativity in all tested regimes to date, but which differ in the ultra-strong field regime relevant to Big Bang cosmology. Granting the success of weak- and medium-field tests of general relativity involving light bending, gravitational redshifting, time delay, and the like, why think that general relativity, rather than one of its (perhaps as-yet unproposed) competitors that fits the data currently in hand, is the right extrapolation? For example, one knows that massive versions of general relativity agree with general relativity in just those regimes, while disagreeing in strong fields [49] (though positive energy has yet to be proven, so Big Bang advocates can still hope that the massive theories are vicious). Massive versions of general relativity violate the energy conditions and tend to bounce at a finite density rather than form singularities, it has been shown. Thus one already has an example that plausibly fits the data just as well as general relativity, while avoiding singularities.

7 Does Quantum Gravity Resolve Singularities?

The need to reconcile gravity and quantum mechanics all but proves that there exists a consistent theory of gravity that matches general relativity in some classical limit, but which differs from it in regimes when dimensional arguments suggest that quantum effects should be large. There might well be many such theories of quantum gravity. There might be classical theories that fit that description as well, such as massive general relativity might be. Theories are, it is widely believed, underdetermined by data. Some small fraction of these theories might have been entertained by physicists on Earth to date. The work of Ashtekar and Bojowald, for example, might indicate that a good quantum theory of gravity is close to being found, though one might have reservations about the flimsy notions of time evolution and causality that it permits. But there is no reason to restrict the competitors of general relativity to theories that someone on Earth has already proposed. The relevant set of competitors for general relativity is the set of theories that agree with general relativity on all experiments to date, whether already entertained on Earth or not. This set might be infinite, might well be large, likely contains several members, and almost certainly has at least one member, a quantum theory of gravity. Moreover, a quantum theory of gravity is likely to differ considerably from general relativity precisely in the ultra-strong field regime of the hot dense 'early' universe. Thus Robert Wald writes: "Of course, at the extreme conditions very near the big bang singularity one expects that quantum effects will become important, and the predictions of classical general relativity are expected to break down." [21, p. 100] In such a context, curvatures comparable to the inverse square of the Planck length arise, so neglected quantum terms should be large and the classical theory becomes a bad approximation. In addition to the modern canonical quantization program, one should also keep an eye on string theory as tending to resolve singularities [50].

Lawrence Sklar once asked "Do Unborn Hypotheses Have Rights?" [51]. Clearly they do in the present context. As Bas van Fraassen has noted in the context of criticizing inference to the best explanation, "We can watch no contest of the theories we have so painfully struggled to formulate, with those no one has proposed. So our selection may well be the best of a bad lot." [52, p. 143] Once the rights of unborn theories are respected, the default status allegedly held by general relativity and hence of Big Bang cosmology disappears. In the ultra-strong field regime of the hot dense 'early universe' (to use a term that presupposes the Big Bang singularity), general relativity is just another speculation among many. Is one truly rationally compelled, or even rationally encouraged, to accept an infinite extrapolation from a curve that fits the data in some finite region? Surely not. Thus sophisticated defenders of scientific realism now admit that different parts of a scientific theory are supported to different degrees by the theory's empirical confirmation [53, chs. 5, 6].

Let us now grant for the moment that there are not presently known alternative theories that remove the singularity. No one can predict reliably that future theories won't achieved what past ones have failed to achieve. Neither can anyone have warrant for saying that theories that no one will ever propose share the defects of current theories such as general relativity. Thus no one now has much warrant for trusting general relativity near its Big Bang singularity.

Moreover, the Leibnizian intuition and the need to use singularity as a criterion for failed theories indicate that the true competitors of general relativity will in at least one case be *superior* to general relativity. Thus one rationally ought to reject general relativity as false in favor of such a competitor.

8 Methodological Problems with Big Bang Arguments

Some of the argumentation above resembles typical worries about 'God-of-the-gaps' apologetic arguments [54]. According to such worries, there is a long history of appeals to SDA to explain certain phenomena, but later natural explanations for such phenomena appeared, making the appeal to SDA unnecessary. Making an induction over this history, one is supposed to learn the lesson not to appeal to SDA in such cases, lest one make religion look foolish once again. It would be interesting to consider the history of such gaps and their closing. Is the alleged series of setbacks for SDA a real phenomenon, or is it akin to the discredited Huxley-Draper-White science-religion warfare thesis [55–57] and the myth that medievals believed in a flat Earth [58]? Whatever the history, several authors recently have argued that there is nothing intrinsically wrong philosophically with arguing from an apparent inadequacy in nature to divine action, because, for example, the argument form is valid [59–61]. Perhaps some gaps arguments are good arguments. Be that as it may, the Big Bang argument is a *bad* argument from gaps to God, because the cosmological singularity *really does* lie squarely in the realm of ordinary providence. This follows not from some antisupernaturalist *a priori* theological claim about what God would or ought to do, made without regard for Scripture, but rather from the singularity theorems, *etc.* of the physics itself. One should not invoke special providence to patch a hole in our understanding of general providence. It is not difficult to imagine the embarrassment that will befall some theistic apologists once a satisfactory theory of quantum gravity resolves the singularity.

A related problem with arguing from the Big Bang to creation in time is that such arguments depend crucially on various highly technical premises which most people cannot even entertain, much less evaluate. It follows that the vast majority of people, even educated ones, simply are not entitled to beliefs on the matter, apart from relying on the testimony of experts. But most people, even most educated people, cannot even reliably identify relevant experts. Most astronomers and most physicists are not relevant experts. Supposing that one manages to identify relevant experts, the problem remains that their expert opinions will or should vary rather rapidly with the winds and waves of research fortune. But should theology be affected much by the validity of Weak or Averaged Null Energy Condition assumed for singularity theorems? It is now known that quantum field theory violates the local classical energy conditions such as the Weak Energy Condition, though apparently quantum field theory still satisfies certain averaged energy conditions: energy density can be negative here and there, but not for very long and only with greater compensation of positive energy in the neighborhood. Nonminimally coupled scalar fields violate energy conditions [62–64], as does massive gravity [49]. Are journalists, sociologists and homemakers supposed to accept an argument whose premises are so technical that they cannot understand them, and so unstable that they could prove false in the next issue of *Physical Review D*? It is not clear why. Should the strength of one's faith depend on which factor ordering for the Hamiltonian constraint is correct in quantum gravity? Martin Bojowald recently wrote in a paper's abstract [43]:

> Because of genuinely quantum geometrical effects the classical singularity is absent in those models in the sense that the evolution does not break down there, contrary to the classical situation where space time is inextendible. This effect is generic and does not depend on matter violating energy conditions, but it does depend on the factor ordering of the Hamiltonian constraint.

Most people have no idea what that means and thus no idea what sort of plausibility to assign a particular factor ordering of the Hamiltonian constraint. If some of them believed in God because of the Big Bang argument, must they now be able to refute Bojowald's choice of factor ordering in order to maintain that belief rationally? Even if the Big Bang argument could not be decisively refuted, could it establish theism to a significant degree for anyone besides the few dozens of people expert in factor ordering in quantum gravity? It is unclear how. (The point having been made, perhaps a brief explanation of the factor ordering problem is appropriate [65]. In classical physics, the Hamiltonian description involves various products of coordinates q and momenta p. In some theories, every term is just a power of q or of p, but not both. But what if there is a term involving powers of both q and p, as is true in Einstein's theory of gravity? Then the order in which they are written, such as p^2q^2 or q^2p^2 or $qppq$ for example, though of no importance classically, is of some importance in quantum theory.)

Given the many difficulties involved in arguing from Big Bang cosmology to creation in time, it is encouraging that Pope John Paul II has suggested that due caution be used regarding the Big Bang argument:

> . . . some theologians, at least, should be sufficiently well-versed in the sciences to make authentic and creative use of the resources that the best-established theories may offer them. Such an expertise would prevent them from making uncritical and overhasty use for apologetic purposes of such recent theories as that of the "Big Bang" in cosmology. [66, pp. M11, M12]

This papal call for caution in apologetic use of Big Bang cosmology compares favorably with the rather less cautious remarks of Pope Pius XII in 1951, which caused concern for Lemaître and McMullin [9, 20].

In this paper I have adopted a skeptical stance toward a certain sort of apologetic for some Christian doctrines. But to deny that a conclusion can be established by a certain argument says little about the efficacy of other arguments. Nothing argued here counts against *teleological* arguments for theism, of the cosmic fine tuning variety or otherwise, for example. Nor is it suggested that accepting creation in time by faith in special revelation renders the belief epistemically suspect [67]. But as far as the Big Bang singularity is concerned, creation in time remains a mystery, known not by physics but by faith. As Hebrews 11:3 puts it, "By faith we understand that the worlds were prepared by the word of God, so that what is seen was not made out of things which are visible." (NASB)

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