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Why the Big Bang Singularity Does Not Help the Kalām Cosmological Argument for Theism

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ABSTRACT

The cosmic singularity provides negligible evidence for creation in the finite past, and hence theism. A physical theory might have no metric or multiple metrics, so a 'beginning' must involve a first moment, not just finite age. Whether one dismisses singularities or takes them seriously, physics licenses no first moment. The analogy between the Big Bang and stellar gravitational collapse indicates that a Creator is required in the first case only if a Destroyer is needed in the second. The need for and progress in quantum gravity and the underdetermination of theories by data make it difficult to take singularities seriously. The singularity exemplifies the sort of gap that is likely to be closed by scientific progress, obviating special divine action. The apparent irrelevance of cardinality to practices of counting infinite sets in classical field theory and Fourier analysis is noted.

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1 Introduction

The epistemic status of theistic belief continues to be of interest. The modern western intellectual climate being skeptical about divine revelation and the supernatural in general, theists seem to be well served if good theistic arguments from natural philosophy are available. One of the more popular theistic arguments, given current science and especially the success of Einstein's General Theory of Relativity (GTR) as applied to cosmology, employs the Big Bang singularity to show that the universe began to exist. This theistic apologetic strategy often proceeds informally, but sometimes by explicit use of the formal Kalām cosmological argument. Whatever the details, this type of argument has commended itself to not a few reputable physicists (as discussed in Jaki [1980]) and other scientists and philosophers, as well as at least one Pope, Pius XII (Pius XII [1952]; McMullin [1981a]). In the 1960s, Engelbert Schücking announced that '[a]lthough some cosmologists might still unconsciously project theological pictures into their science, we have been able to scare most of the ministers out of cosmology by a straightforward application of tensor calculus' (Schücking [1967], p. 218). Schücking notwithstanding, significant and visible efforts continue to be made to support theism *via* the Big Bang singularity. Recent endorsements include the human genome expert Francis Collins (Collins [2007], pp. 64–7) and the new deistic Antony Flew (Flew and Varghese [2007], pp. 135–8). Evidently, some other atheists besides Flew have agreed that Big Bang cosmology supports theism, and so have doubted Big Bang cosmology:

> Perhaps the best argument in favour of the thesis that the Big Bang supports theism is the obvious unease with which it is greeted by some atheist physicists. At times this has led to scientific ideas . . . being advanced with a tenacity which so exceeds their intrinsic worth that one can only suspect the operation of psychological forces lying very much deeper than the usual academic desire of a theorist to support his/her theory. (Isham [1997], p. 378).

While some theists and some atheists hold that the singularity supports theism, both atheists and theists (Drees [1990]; Küng [2007]) have criticized the argument as well. However, atheistic critics not infrequently mix with their good points various unhelpful moves such as denying *ex nihilo, nihil fit* and thus perhaps ceding the rational high ground, introducing premises that strike the theistic apologist as question-begging, or writing in a tone suggesting that rejection of the theistic conclusion plays an undue role in motivating the rejection of the argument. Comparable remarks could be made about some criticisms made by some liberal theists: their *a priori* hostility toward special or detectable divine action in the world might give the impression of bias against arguing from the singularity to theism, and thus blunt the force of their good criticisms.

Judging by the lack of progress in some of the literature, the result is a stalemate (Craig and Smith [1993]; Redhead [1996]). Quentin Smith, who has played a role in critiquing the singularity argument for theism, has a different but also negative evaluation of the overall response to the theistic argument from the Big Bang singularity. Smith ([1992]) held: 'The response of atheists and agnostics . . . has been comparatively weak, indeed, almost invisible'.

Thus there is room, I take it, for a critique of the argument from the Big Bang singularity to theism that strives to convince even the Big Bang singularity argument's proponents, not just the indifferent and the already opposed. If an argument is bad, there is value in showing its badness even to its proponents, if possible. Such a critique will require a brief discussion of the doctrine of creation. It will also involve some concessions to the Big Bang theistic apologist that might otherwise seem overly generous; such concessions will make evident how weak and non-question-begging the premises used in the critique are. The work will have a bit of the flavor of a review article.

The critique presented here also has some novel elements, which should be of direct interest to nontheists and fence-sitters as well. One of these elements is a *reductio ad absurdum* strategy that leads to the conclusion that the Big Bang singularity implies a divine Creator only if stellar gravitational collapse to a black hole implies a theistic Destroyer. Apart from some differences that do not ultimately matter, the scenarios are the same. A second novelty is a strengthening of the conventionality worries by appeal to theories of gravity other than GTR. The Bach–Weyl theory of gravity shows that a physical theory need not even define the length of a curve. In scalar–tensor theories or other theories with multiple metrics, age might be radically ambiguous. Thus, only a topological notion of 'beginning' in terms of a first moment is available if the Kalām argument is intended to yield a necessarily nonvacuous necessary truth. But a first moment is easy to avoid, as will appear below. I will also suggest that some Leibnizian criticisms of the argument from the Big Bang to theism are less persuasive than they are often taken to be.

It should be emphasized that the point at issue is not primarily the soundness of the Kalām cosmological argument, but rather its dialectical effectiveness. A theist might think that the Kalām argument is sound and accept the critique made here, by holding that the key controversial premise of the Kalām argument ought to be accepted not on the grounds of Big Bang cosmology, but only on the basis of divine revelation, which might or might not take the form of an argument of some kind. Theists nowadays increasingly argue that belief in God can be warranted even in the absence of argument (Plantinga [2000]), roughly because God has designed the human mind such that when functioning properly in certain contexts, it forms belief in God. Such (indirectly) divinely caused belief formation is a suitably reliable process to produce knowledge, not just true belief by a happy accident. Thus, Plantinga claims, theistic belief might well be warranted if true; one cannot show that theism isn't knowable apart from showing it to be false (Plantinga [2000]). Clearly, this Reformed epistemology is a form of externalism—the epistemological view that the evidence, warrant, or justification for a belief counting as knowledge need *not* be available to the knower—in contrast to the internalism dominant in the tradition of Descartes and Locke. Whatever the value of Reformed epistemology, the significance of its partial rebellion against Locke's anti-Enthusiast measures (Mavrodes [1989]), or the intricacies of epistemologists' debate over internalism *versus* externalism, the task in this paper is the evaluation of a theistic *argument* of the cosmological sort, in both the philosopher's and the physicist's senses of 'cosmology'. The medieval debate about Aristotle's doctrine of the eternity of the world provides a very helpful precedent.

2 The Doctrine of Creation and Its Warrant

Historically, the doctrine of creation has been basically common property among Judaism, Christianity, and Islam. While there have been some differing views about the doctrine, the differences have little to do with the differences between these religions. A consensus arose that, *pace* Plato's *Timaeus*, creation was *ex nihilo*: God brought (or timelessly brings) all other things into existence and does so without using preexisting materials. Furthermore, God creates the world voluntarily, as a result of willing rather than as an unwilled necessary emanation. Besides the initial creation *ex nihilo* 'in the beginning', there is some sort of ongoing sustenance, preservation, continuing creation or the like, by which God keeps the world in existence and without which it would cease to exist (Quinn [1993]).

Given creation *ex nihilo*, a secondary question is whether God created the world in the finite past or eternally. We may speak of '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.) At times, some have denied the initial creation in favor of God's eternally creating the universe. In medieval times, this denial occurred with not-so-orthodox Islamic philosophers such as Avicenna and Averroes and with the very Aristotelian Averroists in western Christendom. This 'eternal creation' view was defeated by orthodoxy defending creation in time. In western Christendom, this defeat took institutional form in the Fourth Lateran Council in 1215 and the condemnations by Bishop Tempier of Paris in 1277.

Advocates of creation in time have disagreed whether the finite age of the universe could be known by reason or only by faith (Thijssen [1998]). 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 the philosophical arguments of their days in favor of a finite age to be inconclusive. Thus the issue was left to be resolved by Scripture, which favored finite age (Hyman and Walsh [1973]). Bonaventure, by contrast, took the finite age of the universe to be demonstrable philosophically. This distinction is closely analogous to the issue addressed in this paper. Those who argue for theism from the Big Bang singularity follow Bonaventure in spirit. I will argue that theists who affirm creation in time ought to hold, with Maimonides and Aquinas in spirit, that creation in time is known by faith rather than by natural philosophy—or at least, not from the singularity in Big Bang cosmology.

Apart from the thirteenth-century Aristotelian controversy over the eternity of the world, there seems to have been little controversy in Christian circles about creation in time until modern theology arose. As Langdon Gilkey writes, '[u]ntil the nineteenth century, almost every Christian thinker accepted this dual implication [involving a temporal origin as well as metaphysical dependence] of the doctrine of creation: God long ago brought the world into existence out of nothing at a first moment of the time series. To all of them it seemed the clear message of the first verse of Genesis' (Gilkey [1959], p. 311). In modern theology, the initial creation was downplayed by Friedrich Schleiermacher as not necessitated by his controlling principle of the feeling of absolute dependence (Russell [1996b]). Moreover, he took the doctrine of the initial creation event to depend on the *Genesis* creation account, which he took to be the product of a mythological time (Copan and Craig [2004], pp. 150, 151). Quite a few modern scholars have felt free to discard or hold lightly the initial creation event, so eternal creation is now regarded as attractive in some circles (Gilkey [1959]; Polkinghorne [1994]; Russell [1996a]; Helm [1997]). According to John Polkinghorne, '[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' (Polkinghorne [1994]). Paul Helm has agreed (Helm [1997]). On the other hand, Phil Quinn offers an account in which creation implies a first moment; thus if an object has no first moment, God doesn't create it, though he conserves it in existence (Quinn [1993]). The question has also arisen whether Genesis 1:1 actually asserts a beginning or not, but the traditional interpretation still certainly has defenders (Copan and Craig [2004]). It should go without saying that the interpretation of a text is a distinct issue from the correctness of its assertions.

If a universe is created, 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. The universe's having a first moment entails it being finitely old (unless one introduces a point at infinity, which seems purely formal), but the converse entailment might fail. If time is continuous, then the world's being finitely old does not entail it having a first moment. At least *prima facie* it seems that a universe with a first moment is the sort most confirmatory of theism (McMullin [1981b]), while an eternal universe is the least helpful. Regarding the two extreme cases, Aquinas held something along these lines, as Ernan McMullin discusses (McMullin [1981a], p. 39):

> 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.

It seems that a first moment conveys three advantages on a 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 (Grünbaum [1989]; Earman [1995]; Smith [2000]).

Second, having a first moment is a topological notion, not a metrical one, and so escapes conventionality worries (Misner [1969]; Agnese and Wataghin [1971]; McMullin [1981a]; Grünbaum [1989]; Levy-Leblond [1990]) about temporal remetrization of a finite past to an infinite one. Conventionalist questions about the significance of the difference between finite *versus* infinite seem to be due to E. A. Milne (Kragh [2004], p. 209; McMullin [1981a]). 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?' (Magnano and Sokolowski [1994]; Weinstein [1996]; Kaloper and Olive [1998]; Santiago and Silbergleit [2000]). 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, positive energy, and quantization give that question a bit more urgency (Kaloper and Olive [1998]; Santiago and Silbergleit [2000]; Faraoni and Nadeau [2007]; Catena *et al.* [2007]; Sotiriou *et al.* [2008]). Theories with multiple metrics might have different types of matter coupling to gravity in different ways; then perhaps one metric might yield finite age, but another infinite age, in which case there seems to be no answer to the question 'how old is the universe?', even if the options at hand are merely 'finite' and 'infinite'. It turns out that the actual universe probably does not behave in accord with a scalar–tensor theory, given the empirical confirmation of the various principles of equivalence in gravity (Will [1993]), which make it difficult for theories empirically distinguishable from GTR in weak or moderate gravitational fields to be empirically viable. But a doctrine of creation needs to be modally rich enough to accommodate the possibility of God's creating worlds with physical laws without a unique or preferred metrical structure to license an answer of 'finite' or of 'infinite' age.

Third, a first moment, being topological rather than metrical, is well defined even in the absence of a metric. Bach–Weyl conformal gravity (Fiedler and Schimming [1980]; Schimming and Schmidt [1990]; Kazanas and Mannheim [1991]; Dzhunushaliev and Schmidt [2000]), in the absence of matter or with some types of matter, employs only the conformal part $\hat{g}_{\mu\nu}$ of a metric, a tensor density with weight $-\frac{1}{2}$ (in four space-time dimensions) and determinant -1 (Anderson [1967]). Given a metric $g_{\mu\nu}$, one can obtain its conformal part using

$$\hat{g}_{\mu\nu} = g_{\mu\nu}[-det(g_{\alpha\beta})]^{-\frac{1}{4}} \quad (1)$$

(in four space-time dimensions). Not having a metric, the Bach–Weyl theory takes $\hat{g}_{\mu\nu}$ as primitive and does not assign lengths to curves.[1] While light-like (null) geodesics are well defined in the Bach–Weyl theory, their affine parametrization is not (Wald [1984], p. 446), so even light-like (null) geodesics provide no help in defining finite age. By contrast, Copan and Craig simply take for granted the existence, and perhaps the uniqueness, of the metric for timelike curves in setting up the Kalām argument (Copan and Craig [2004], p. 199) (here presented a bit differently from the version quoted below):

> To assess the truth of the premise [that the temporal series of past, physical events is not beginningless], it will be helpful to define some terms .... In order that all the events comprising the temporal series of past events be of equal duration, we arbitrarily stipulate some event as our standard .... By

[1] The Lagrangian density of the Bach–Weyl theory is the square of the Weyl curvature tensor $C_{\rho\sigma\nu}{}^{\mu}$. The Weyl tensor in its natural habitat is a (1, 3) tensor and is a concomitant of the conformal metric density without the determinant $g =_{def} det(g_{\alpha\beta})$, so it is itself conformally invariant (Anderson [1967]; Wald [1984]). (Anderson has a misprint on p. 84 on this very point; one index of the Weyl tensor should be raised, as in $C_{\rho\sigma\nu}{}^{\mu}$, or else the index should be lowered with $\hat{g}_{\mu\nu}$ (not $g_{\mu\nu}$), thereby giving a densitized Weyl tensor.) Thus the Lagrangian density is (up to a constant factor) $\hat{g}^{\rho\alpha}\hat{g}^{\sigma\beta}C_{\rho\sigma\nu}{}^{\mu}C_{\alpha\beta\mu}{}^{\nu}$. The absence of g has been made manifest by the use of the inverse conformal metric tensor density $\hat{g}^{\mu\nu}$, which has density weight $\frac{1}{2}$, and the primordial (1, 3) form of the Weyl tensor. Much like the Maxwell electromagnetic kinetic term $\hat{g}^{\mu\alpha}\hat{g}^{\nu\beta}F_{\mu\nu}F_{\alpha\beta}$, the Bach–Weyl Lagrangian density is a weight 1 scalar density (as is required for a coordinate-invariant stationary action principle), but it does not depend on g, and so is manifestly conformally invariant.

> a 'beginning,' one means a first standard event. It is therefore not relevant whether the temporal series had a beginning point (a first temporal instant).

Copan and Craig perhaps take their Kalām argument to express a necessary truth that applies nonvacuously to all possible physical theories. However, their criterion for a beginning is meaningless for the Bach–Weyl theory because 'equal duration' is meaningless in that theory. The Copan–Craig criterion might be ambiguous for scalar–tensor theories, which is also somewhat worrisome. Given that neither existence nor uniqueness of a metric (for timelike curves) holds necessarily, the natural move is to adopt a topological rather than a metrical notion of beginning. Thus a first moment *is* the point that needs to be addressed. However, to adopt a first moment as the criterion for a beginning is to admit defeat, as far as arguing from the singularity to theism is concerned, because the two plausible moves relative to contemporary cosmology (*viz.*, taking space-time to contain only points 'after' the singularity or invoking some perhaps presently unknown theory that resolves the singularity, and so permits an infinite past) lack a first moment. Given the demonstrable contingency of the existence and uniqueness of a metric, and the contingent relationship between the tensor $g_{\mu\nu}$ and physical lengths (which depends on how matter couples to gravity (Brown [2005]), it is unclear why finite metrical age is so important even for GTR.

As it turns out, the Fourth Lateran Council in 1215 made it a doctrine of faith, at least for Roman Catholics, that the world had a temporal beginning, and even escapes the conventionalist worry by positing a first moment (McMullin [1981a], pp. 29, 54, 55) (cf. Grant [1994], p. 83; Leith [1982], p. 57). The council's definition apparently is topological rather than metrical in character, so its intelligibility withstands the mathematical advances of the last 700–800 years. Whatever one makes of the contemporary relevance of the canons of the Fourth Lateran Council as a deliverance of faith—only traditional Roman Catholics will feel bound to accept the council's teaching, while its stipulation that the angels were created at the same moment (Leith [1982], p. 57) poses an additional burden for belief—this conciliar conclusion about a first moment of the physical universe is clearly not a deliverance of reason.

As McMullin and Aquinas observe, creation in time does have some theological advantages over eternal creation, even apart from adherence to the relevant part of the Genesis account. On the other hand, the epistemology of creation, at least for the author of the letter to the Hebrews in the New Testament, might favor Aquinas rather than Bonaventure. A key passage is Hebrews 11:3: 'By faith we understand that the universe was created by the word of God, so that what is seen was not made out of things that are visible' (ESV). In light of this passage (similar in other translations, though not in the RSV), perhaps Christians should expect that philosophical or scientific demonstrations for creation in time will fail. In any case, current demonstrations from the Big Bang singularity fail.

3 Cardinality and Sizes of Infinity

A few brief comments on Craig and Copan's *a priori* arguments for a finite past will be useful. Regarding the supposed impossibility of traversing an actual infinity (Craig [1979]; Copan and Craig [2004]), one might object to the treatment of infinity (Morriston [2003]; Redhead [1996]). Concerning the possibility of the existence of an actual infinity, there is no evident absurdity in Hilbert's hotel, which has as many rooms as there are positive integers. It is also difficult to regard as omnipotent a God who could not create Hilbert's hotel. If the occurrence of a beginning of time could be known *a priori*, then arguments from physical cosmology would be largely redundant. For the sake of argument (and other reasons as well), I therefore assume that an infinite past is metaphysically possible.

It appears that Craig's objections to the possibility of actual infinities, such as Hilbert's hotel, are due in no small part to the widespread claim that the concept of size is fully captured by the notion of cardinality. But one might well accept the possibility of actual infinities, such as Hilbert's hotel, while doubting that cardinality exhausts the notion of sameness of size or counting. Indeed, contemporary physics implicitly denies that cardinality exhausts the notion of sameness of size or counting for infinite sets: physicists routinely count the number of degrees of freedom in a field theory as two at each spatial point (written as $2\infty^3$ in three spatial dimensions), or three at each spatial point (written as $3\infty^3$), or the like (Sundermeyer [1982]; Henneaux and Teitelboim [1992]). Whereas Maxwell's electromagnetic theory has $2\infty^3$ degrees of freedom, Proca's electromagnetism with massive photons (to borrow a quantum phrase), a theory (or family thereof) worthy of consideration in discussions of underdetermination and empirical equivalence, has $3\infty^3$ degrees of freedom. Physicists never feel bound to perform, or even entertain, such Cantorian manipulations as $2\infty^3 = \infty$, $3\infty^3 = \infty$, and therefore $2\infty^3 = 3\infty^3$, so that Maxwell's and Proca's theories have the same number of degrees of freedom. Such manipulations would reduce some important reasoning in field theory and constrained dynamics to nonsense. The lesson seems to be that physical theories involve continuity properties of sets from which cardinality abstracts, and that it seems reasonable to call the results 'counting' nonetheless. Evidently, cardinality does not exhaust the useful notions of 'same size' or counting in all contexts. A related point pertains to the mathematics of Fourier analysis of arbitrary functions in terms of sinusoidal functions: for finite intervals of the real line, one can represent functions using a Fourier series with countably infinitely many coefficients, whereas for the whole real line one represents functions using a Fourier integral with uncountably many coefficients (Jackson [1975]), though the finite interval and the whole real line have the same cardinality. These important parts of applied mathematics do not obviously have a straightforward connection to cardinality. It seems inadvisable, then, to say that cardinality simply *is* the notion of size or counting for infinite sets (though its technical utility in some contexts is undeniable). Thus one can perhaps sympathize with some of Craig's mathematical motivations for *a priori* objections to actually infinite collections. However, no good argument against their possibility results.

4 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 space-time metric satisfying Einstein's gravitational field equations (Wald [1984]). This metric is spatially homogeneous and isotropic, meaning that every point in space is alike at a given moment of time, and so is every direction. 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, which might allow depiction of all objects as shrinking). The dynamics of GTR, 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. During the hot dense phase, the material contents of the universe would be radiation or matter closely approximating radiation in its equation of state relating pressure and density. Given the form of the stress–energy–momentum tensor for radiation, GTR predicts (or retrodicts) that the universe would expand roughly as $a(t) \sim \sqrt{t}$, where a is the scale factor and t measures physical proper time, the 0 corresponding mathematically to the Big Bang singularity. This behavior is exact for the (idealized) spatially flat case, and holds as an increasingly good approximation as $t \rightarrow 0$ in the positively or negatively spatially curved cases (Wald [1984], p. 98).

One theoretical problem that frequently has been neglected is the 'averaging problem', the need to average Einstein's equations over cosmic distances in order to find equations for the cosmic parameters (Ellis [1984]; Zalaletdinov [1992]; Buchert and Carfora [2002]; Coley and Pelavas [2006]). The analogous procedure for electromagnetism in a medium is well known and comparatively simple due to the linearity of Maxwell's equations (Jackson [1975]; Mars and Zalaletdinov [1997]). For Einstein's equations, the dynamics of the average bears a complicated relation to the average of the dynamics, so to speak, due to nonlinearities. Experimentally, since the late 1990s it has appeared that the cosmic expansion is accelerating. However, some contend that paying attention to the averaging problem might help to resolve the apparent phenomenon of accelerating expansion, for which 'dark energy' has been posited (Buchert [2008]) as an explanation or at least a name. It has also been argued that part of the persuasiveness of the acceleration of the cosmic expansion is an artifact of conventional choices of statistical variables (Cattoen and Visser [unpublished]), or that a deeper failure of homogeneity might require consideration (Ellis [2008]). Little turns on these issues for my purposes, because using the most current version of Big Bang cosmology with accelerating expansion does nothing to strengthen the Big Bang singularity argument for creation and time, and hence theism. The same could be said for inflation, which John Earman and Jesus Mosterin have examined critically (Earman and Mosterin [1999]). I will freely ignore these more recent developments in favor of the old hot Big Bang cosmology.

Given the observed cosmic expansion, mathematical extrapolation still further into the past—a bold move that might have little warrant, depending on how far one extrapolates—implies that the space-time 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. It should be emphasized that extrapolation over small periods of time near $t = 0$ corresponds to extrapolation through an extraordinary range of energies, into realms far beyond the reach of particle accelerator experiments. Contrary to some earlier hopes (Earman [1995], p. 205) 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 (Wald [1984]). 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 (Bondi [1947]; Layzer [1954]; McCrea [1955]; Callan *et al.* [1965]; Klein [1971]; Feynman *et al.* [1995]; Smoller and Temple [2003]; Adler *et al.* [unpublished]), not an empirical fact. Indeed, even the global topology of space-time is subject to worries regarding conventionality (Glymour [1973]; Malament [1977]). Empirically we have no (direct) access to regions more distant than some billions of light years (at least apart from quantum mechanics), due to relativistic causality constraints. As a result, claims that homogeneity holds out to, say, a trillion light years, or 10^{30} light years, are not observationally well grounded (Earman [1995], p. 125; McCabe [2004]). (Of course, inflationary cosmology could complicate matters.) I emphasize the spatially local rather than global nature of current cosmological knowledge, and hence of the singularity, in anticipation of discussing the analogy between

Big Bang cosmology and the time reversal of stellar gravitational collapse. If one wishes to think of Big Bang cosmology as involving, say, a sufficiently vast expanding ball of matter surrounded by empty space, the data supporting hot Big Bang cosmology provide no obstacle; of course, the Robertson–Walker metric will not apply in the exterior vacuum region. 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' (Kragh [2004], p. 57). It is not difficult to see how finitism could serve teleological world views by reducing the probabilistic resources for unguided evolutionary processes, or how its denial could serve nonteleological world views, but experiments have not resolved the issue and perhaps cannot.

Just 'where' in the space-time metric the Big Bang singularity lies deserves some comment. Inverting a relation above, one can break the space-time metric down into a conformal factor $\hat{g}_{\mu\nu}$ and a factor of the metric's determinant, which determines volumes

$$g_{\mu\nu} = \hat{g}_{\mu\nu}[-det(g_{\alpha\beta})]^{\frac{1}{4}}. \qquad (2)$$

Given that Big Bang cosmology is glossed as involving the expansion of the universe, and that this expansion is isotropic, one might think that the metric tensor $g_{\mu\nu}$ becomes singular in the part that determines volumes, the determinant $g =_{def} det(g_{\mu\nu})$. That cannot be the case, however, because one can achieve $g = -1$ in some neighborhood about any given point, a well-known fact that recently was seen to have deep consequences for analyzing the 'general covariance' that supposedly characterizes the conceptual innovation of GTR (Pitts [2006]; Giulini [2007]). The Big Bang singularity cannot be a property of $\hat{g}_{\mu\nu}$, because $\hat{g}_{\mu\nu}$ is the same as in the Minkowski flat space-time of Special Relativity, on account of the conformal flatness of the Robertson–Walker metrics (Infeld and Schild [1945]; Tauber [1967]). For the same reason, the Big Bang singularity cannot manifest itself in bad behavior of the Weyl curvature tensor, which in fact vanishes for the Robertson–Walker metrics due to their conformal flatness.[2] It follows that the Big Bang singularity manifests itself in the misbehavior of the relation between $\hat{g}_{\mu\nu}$ and g, which also manifests itself in the Ricci (or equivalently, the Einstein) curvature tensor.

While a number of people noted above have regarded the Big Bang singularity as potent evidence for creation in time and hence for theism, perhaps the most visible sustained defenses have come from Craig (Craig [1979]; Craig

[2] For other space-time metrics, it can happen that a singularity manifests itself in the conformal metric density $\hat{g}_{\mu\nu}$ (Tod and Lübbe [unpublished]). The usual Big Bang is just not such a case. Thus the Big Bang singularity forms no insurmountable barrier in the Bach–Weyl theory, for example, because g is absent from that theory.

and Smith [1993]; Copan and Craig [2004]) and from astrophysicist–apologist Hugh Ross (Ross [1991], [2001]). While Ross's works generally are not aimed at the academy, they receive endorsements by some reputable physicists and astronomers such as Donald Page and Allan Sandage, generously cite technical papers and have some semi-popular influence. As Ross puts the issue,

> [i]n Hawking's words, time itself must have a beginning. [footnote omitted] Proof of the beginning of time may rank as the most theologically significant theorem of all time, assuming validity of the general theory of relativity (Ross [2001], p. 102).

The conditionalizing on GTR soon disappears, however, with a ringing endorsement of that theory:

> Today it can be said that no theory of physics has ever been tested in so many different contexts and so rigorously as general relativity. The fact that general relativity has withstood all these tests so remarkably well implies that no basis at all remains for doubting the conclusions of the space-time theorem (Ross [2001], p. 107).

By contrast, William Lane Craig argues more carefully and concludes more modestly. Craig formulates the Kalām cosmological 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 (Craig [1979], p. 63).

This argument is valid, at least if it is unproblematic to treat the universe as a thing, rather than a collection of things; I assume that there is no problem here. The first premise seems true (apart from worries about virtual particles in quantum field theory, perhaps), at least on some readings of 'beginning', including the one for which I argued above, namely, a first moment—though that is not Craig's reading. The truth of the second premise, or rather, the source of warrant for the second premise if it is true, is the key question. Many theists will affirm the second premise and regard the Kalām argument as sound, but what is the reason for affirming the second premise? Clearly, one will not persuade the nontheist to accept theism (or strengthen the theist's faith with scientific support), as the argument is intended to do, if the warrant for the second premise comes wholly from ostensible divine revelation. If one accepts, say, the Bible as divinely inspired, then one has already accepted theism and much else besides.

5 Tolerance or Intolerance toward Singularities?

The question therefore arises whether to take the singularity seriously as a feature of the real world, or to dismiss it as an artifact of incomplete physical understanding. As one sees all the time in papers on quantum gravity, most people who work on quantum gravity take for granted that the Big Bang singularity is an artifact of incomplete physical understanding and expect or hope that uniting gravity with quantum mechanics in some kind of quantum gravity will resolve the singularity into some well-defined situation that admits extrapolation to still earlier times, *ad infinitum*. Jayant Narlikar has persuasively deployed this point as a critique of the argument from the singularity to theism (Narlikar [1992]). Earman, by contrast, defends a less widely held view about singularities, namely, that we should display 'Tolerance for Spacetime Singularities' (Earman [1996]) and try to learn from them.

Tolerating singularities and trying to learn from them, as Earman does, is an attitude that should commend itself only to GTR-exceptionalists, those who emphasize the differences between GTR and the other forces over the similarities between them. If one thinks that gravity as portrayed by GTR is importantly like other forces, then gravitational singularities are not appreciably more interesting than the singular electric field of a point charge, which simply needs to be resolved by a better theory, such as quantum electrodynamics. Thus 'complete gravitational collapse [in that case is u]nimportant or at most peripheral' (Misner *et al.* [1973], p. 437). But if gravity differs importantly from the other forces, one might conclude that 'complete gravitational collapse [is c]entral to understanding the nature of matter and the universe' (Misner *et al.* [1973], p. 437). Then, however, one has strong technical reasons to doubt that singularities exist as part of space-time.[3] Within the Robertson–Walker cosmological space-time for $t > 0$ (which is to say, always), one can explain each moment in terms of an earlier one (Grünbaum [1989]; Earman [1995]; Smith [2000]). Thus there is no beginning required and premise 2 might be false, as far as physics can tell. Those who strive to 'take the lessons of relativity seriously', as GTR-exceptionalists do, might also have reason to doubt the evolutionary space-evolving-over-time picture in favor of some inherently four-dimensional picture. If one rejects the demand for such evolutionary explanations as a hangover from Newtonian physics, then again the space-time for $t > 0$ seems sufficiently self-explanatory that the singularity gives no reason to infer a Creator.

In contrast to GTR-exceptionalism, one might take the view, more common among particle physicists but not well known among philosophers, that

[3] One might have other reasons for doubting that singularities exist as part of space-time if one emphasizes the analogy between gravity and other forces (Pitts and Schieve [2003]).

Einstein's equations merely describe a self-interacting massless spin 2 field, much as Maxwell's equations describe a spin 1 field and the Yang–Mills equations describe a set of self-interacting spin 1 fields (Fierz and Pauli [1939]; Rosen [1940]; Papapetrou [1948]; Gupta [1954]; Kraichnan [1955]; Feynman *et al.* [1995]; Ogievetsky and Polubarinov [1965]; Weinberg [1965]; Sexl [1967]; Deser [1970]; Weinberg [1972]; van Nieuwenhuizen [1973]; Veltman [1981]; Fang and Fronsdal [1979]; Pitts and Schieve [2001]; Boulanger and Esole [2002]); the distinctive features of GTR are seen as incidental (though important) technical consequences of gravity having spin 2 rather than spin 1. While probably all who tolerate singularities are GTR-exceptionalists, many or most GTR-exceptionalists, such as those who work on canonical quantum gravity and loop quantum gravity, do not tolerate singularities.

It appears, then, that whether one is tolerant or intolerant toward singularities, it turns out that there is no first moment (unless one is installed by hand), because every moment is preceded by earlier moments. Thus, in the relevant sense for the Kalām argument to be valid and to make sense for a sufficiently broad collection of physical theories, there is no beginning implied by physics, and so premise 2 might be false, as far as physics can show. In order for the Big Bang singularity to provide a good theistic argument, the singularity must be well enough behaved to be a real and intelligible part of space-time, and badly enough behaved that it cannot have a past. Satisfying both conditions seems difficult and unlikely to be achieved. Moreover, there are various reasons, some quite good, for not tolerating singularities, which it will be worthwhile to explore.

6 Leibniz against Incompetent Watchmaker?

One might think that Leibniz has provided the prototype for a good critique of the singularity argument for theism. In the Leibniz–Clarke correspondence (Alexander [1956], 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 on occasion to restore the solar system to working order. Whereas one sometimes encounters biological dysteleology arguments, this is a physical dysteleology argument. Whether Newton and Clarke deserved this criticism need not concern us. Acceptance of Leibniz's analogy between the physical world and a watch did not require a rejection of miracles, for Leibniz accepted miracles of grace, while rejecting miracles posited to fix nature due to poor design (Alexander [1956], p. 12). If the physical world is like a watch, then it ought to be able to run forever without breaking down.

But the singularity theorems of GTR show that it cannot 'run forever without breaking down'. (There is no obvious analogy to the repair of the watch.) Thus the singularity theorems arguably show that GTR demonstrates its own inadequacy, one might conclude. Because God would not build the world so incompetently, it follows that GTR is not the correct theory for describing gravitational collapse; the true theory would not yield singularities. But GTR is time-reversal invariant, and the Big Bang singularity is simply the time reversal of a specific model of gravitational collapse of a star, which uses a Robertson–Walker metric for the stellar interior (Misner *et al.* [1973], pp. 846–59). Thus the Big Bang singularity would be eliminated along with the singularities of gravitational collapse, or so the argument might go.

This sort of argument continues to be used today, often without the explicit theism, by theoretical physicists. 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 GTR, 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?. . . (Ashtekar [unpublished]).

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

Leibniz might or might not have been entitled to his 'God wouldn't do it that way' premise. He lived in a still Christian age and took himself to know many things by divine revelation; many contemporary physicists cannot say the same. If one is doing natural rather than revealed theology, the premise about what God would or wouldn't do seems difficult to justify. Thus Elliott Sober has recently warned against this sort of *a priori* theological claim about what God would or ought to do (Sober [2003], [2007]). Whereas Stephen Jay Gould seemed to think that he knew that God (if he had existed) wouldn't have made the panda's thumb as it is, Sober denies that Gould knew any such thing about the dispositions of the deity.

The Leibnizian intuition that the world would not break down after a finite time has a certain appeal for physicists, but reflection suggests that it might be difficult for the argument to get traction with those not already disposed to accept it, except perhaps for theistic rationalists such as Leibniz. That this Leibnizian intuition (perhaps stripped of its theistic justification) in fact appeals to physicists may reflect the fact, discussed in theories of science by Thomas Kuhn, Imre Lakatos, and others (Laudan *et al.* [1986]), that ordinary scientific progress depends upon a certain faith that things are on the right track and that progress is possible; anomalies that could serve as counterevidence are in fact typically not regarded as threatening the paradigm or hard core of the research programme, but rather as opportunities to display its excellence, sooner or later, by triumphing over difficulties, while causing no alarm in the mean time. The Leibnizian intuition might well be truth-conducive, but it is difficult to argue for that conclusion. This phenomenon bears some resemblance to the sort of stalemate that can result in the scientific realism–antirealism debate (Kukla [1998]). However, the sort of intellectual pessimism or strong empiricism that rejects the Leibnizian intuition, if accepted, might undermine the explanatory drive that motivates accepting premise 1 of the Kalām argument.

7 Induction from Earlier Theories' Breakdown?

The physics of a century ago provides some material for an inductive argument that quantum mechanics will fix the problems in Einstein's classical theory of gravity. The story of blackbody radiation and the development of quantum theory is complicated (Kuhn [1978]), more so than the view given in modern physics textbooks, but the following selection should suffice. 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. Lakatos has already extolled the virtues of rationally reconstructed history.) 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* of the classical physics underlying the Rayleigh–Jeans radiation law. The solution was new physics of a quantum kind, which averted the catastrophic infinity; no miracle was required. Using this case and others, one might argue inductively that just as quantum mechanics resolved these problems, so it will resolve the singularity problems of GTR.

Earman insightfully discusses a similar argument to the effect that GTR contains the seeds of its own destruction (Earman [1996]), citing Kip Thorne's invocation of the Rutherford atom. However, as Earman notes, the Rutherford atom with classical electromagnetism was empirically inadequate, something that cannot be said at present for GTR's prediction of gravitational collapse. A theory that predicts disaster here and now clearly needs to be changed, if disaster is not observed. However, GTR fits the data rather well. What of its ultimate mathematical breakdown in singularities? Earman observes that if GTR is taken at face value, then there just is not some region 'beyond' the singularity that the theory fails to describe. It would seem that the supposed inductive argument relies on a metatheoretic criterion besides empirical adequacy to determine that GTR breaks down, one that strongly resembles the Leibnizian intuition previously discussed. Thus '[t]he analogy with the Rutherford atom is not apt' (Earman [1996]). So this inductive argument will not persuade those who are not persuaded by the Leibnizian intuition. But there are more compelling reasons for rejecting the argument from the Big Bang to theism.

8 Stellar Collapse Implies Theistic Destroyer

One might wonder why theological significance should be ascribed 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. Assuming homogeneous matter distributions, both Big Bang cosmology and stellar gravitational collapse use the Robertson–Walker space-time metric in the matter-filled region (Misner *et al.* [1973], pp. 846–59). If one chooses a Big Bang model with a bounded matter distribution, as one certainly may (Bondi [1947]; Layzer [1954]; McCrea [1955]; Callan *et al.* [1965]; Klein [1971]; Feynman *et al.* [1995]; Smoller and Temple [2003]; Adler *et al.* [unpublished]) (though typically one doesn't, partly for convenience), then both the Big Bang and the gravitational collapse have a Robertson–Walker interior matched to a Schwarzschild exterior. The main differences are the direction of time and the distance scale. The distance scale does not seem important for present purposes. 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 interiors of stars?

That God is the Destroyer of collapsed stars is a rather surprising conclusion. While Christianity portrays God as creating, sustaining, and redeeming the world, the idea of God's absolutely annihilating either the physical world as a whole or a bit here and there from time to time appears to be a novelty or certainly a rarity in Christian theology. Of course rocks, buildings, and animals perish from time to time, but their physical remains persist, which is precisely what does *not* happen in the stellar case. Orthodoxy has held generally that even those who 'perish' in hell (presumably the best candidates for ceasing to exist) in fact persist forever, body and soul, albeit in a miserable condition. Given the divine policy of upholding the universe after creating it, for God to stop upholding, say, a star that collapses to a black hole, would be a miracle. Annihilating an object (ceasing to uphold it in existence) might not be the same kind of miracle as creating one *ex nihilo*, but it is a miracle nonetheless. I would not be appreciably less astonished by witnessing the sudden annihilation of my car than by seeing the abrupt appearance *ex nihilo* of a horse. Thus, whatever asymmetry of time might exist in relation to causation, it does not help to avoid the conclusion that stellar gravitational collapse terminates in a miracle. The proponent of the Big Bang argument therefore needs to explain why the termination of stellar gravitational collapse is not a miracle, or why such a miracle is not pointless and hence absurd. It is somewhat comforting that God, on the view in question, would only annihilate regions of high density, perhaps typically surrounded by an event horizon. Thus there is plenty of warning so that we may avoid these episodes of annihilation, and the farmer who stores wheat in a silo need not fear the annihilation of his wheat. But the theoretical oddness remains. The theological distinction between ordinary and special providence, though probably never absent historically (else the distinction between miracles and ordinary events would be meaningless or hopelessly vague), received a boost in the twelfth century in the west (Grant [1996], pp. 21, 22) and even achieved confessional status (not mere general acceptance) in the Westminster Confession of Faith (1646):

> God, in His ordinary providence, maketh use of means, yet is free to work without, above, and against them, at His pleasure (Chapter 5, Section 3) (Leith [1982], p. 200).

Given this robust (though qualified) affirmation of the general integrity of natural processes, which likely was shared outside the Reformed tradition that produced the Westminster standards, the claim that God annihilates collapsed stars would have seemed odd even to pre-Enlightenment orthodox believers (if we may imagine them informed about twentieth century physics), for whom miracles were no embarrassment. If GTR were the only possible theory to describe the divine governance of the world in matters gravitational, perhaps one could manage to accept the conclusion that God miraculously destroys collapsed stars. But given the underdetermination of theories by data and consequent avoidability of that conclusion, that inference appears to be a *reductio ad absurdum*.

9 Stacking the Deck for GTR

There is a misleadingly persuasive move made by proponents of the Big Bang argument, stacking the deck in favor of GTR 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 GTR are speculative, whereas GTR is well confirmed, so GTR 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 in the more speculative literature do not form part of a well-tested theory that is known to reproduce the empirical successes of GTR. Thus some 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. Were the physics community's (or its members') physical knowledge closed under logical entailment, such would-be challengers would be refuted even before publication; alas, human finitude intrudes, and it sometimes takes hard work to show whether a theory is consistent with present empirical knowledge. Thus one cannot simply collect dozens of papers that discuss nonsingular cosmological models and thereby 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 GTR 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 GTR involving light bending, gravitational redshifting, time delay, and the like, why think that GTR, rather than one of its (perhaps not yet unproposed) competitors that fits the data currently in hand, is the right extrapolation? For example, one knows that massive variants of GTR (relating to GTR as Proca's electromagnetism does to Maxwell's) agree with GTR in just those regimes, while disagreeing in strong gravitational fields (Visser [1998]; Babak and Grishchuk [2003]), including those near the alleged cosmic singularity. However, positive energy has yet to be proven and might be false for massive variants of GTR (Boulware and Deser [1972]; Pitts and Schieve [2007]), so Big Bang singularity apologists can still hope that the massive theories are vicious. Apologists for (or rather, from) the singularity need to hope that a great many epistemically possible theories are vicious, in fact, a hope that most likely will disappoint eventually, if it has not already.

10 Quantum Gravity Tends to Resolve Singularities

The need to reconcile gravity and quantum mechanics all but proves that there exists a consistent theory of gravity that matches GTR 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. The works of Abhay Ashtekar and collaborators, such as (Ashtekar *et al.* [2006a], [2006b]), and Martin Bojowald and collaborators, such as (Bojowald [2001a], [2001b], [2002]; Bojowald and Hinterleitner [2002]; Bojowald and Kagan [2006]), provide good evidence that the Big Bang singularity does not occur in loop quantum gravity (but see Cartin and Khanna [2005]). Loop quantum gravity is a part of the modern nonperturbative canonical quantum gravity project (Pullin [2003]), which began in the 1980s when Abhay Ashtekar proposed new variables that helped to resolve long-standing problems faced when using the older metric variables.

Moreover, a quantum theory of gravity is likely to differ considerably from GTR precisely in the ultra-strong field regime of the hot dense 'early' universe, where the Big Bang arguer relies essentially on GTR! Thus Robert Wald writes in a standard graduate textbook on GTR: '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 GTR are expected to break down' (Wald [1984], 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 (Gasperini and Veneziano [2003]), not to mention various classical proposals that alter the dynamics in the strong field regime.

Lawrence Sklar once asked 'Do Unborn Hypotheses Have Rights?' (Sklar [1985]). Clearly, they do in the present context. As Bas van Fraassen has noted in the context of criticizing inference to the best explanation, '[w]e 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' (van Fraassen [1989], p. 143). P. Kyle Stanford argues that the problem of unconceived alternatives is an even more serious problem for scientific realism than are more commonly discussed worries (Stanford [2006], [2001]). Once the rights of unborn theories are respected, the default status allegedly held by GTR and hence of Big Bang cosmology as described by GTR near the singularity disappears. In the ultra-strong field regime of the hot dense so-called 'early universe' (to use a term that presupposes the Big Bang singularity), GTR 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. This is a severe curve-fitting problem. 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 (Psillos [1999], Chapters 5, 6). In the context of GTR, one should recognize that the theory's success in weak- and medium-strength gravitational fields provides little support for the theory's accuracy in strong gravitational fields such as near the Big Bang. But there is no reason to restrict the competitors of GTR to theories that someone on Earth has already proposed. The relevant set of competitors for GTR includes the set of theories that agree with GTR 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. The set most likely has at least one member that resolves the singularities of GTR. Thus it is not at all clear why one should take GTR seriously in the strong-field regime near the supposed Big Bang singularity. Certainly, Einstein did not (Earman and Eisenstaedt [1999]).

11 Vicious God-of-the-Gaps Character

Regarding the argument from the Big Bang singularity to theism, Chris Isham notes 'its obvious susceptibility to the "God of the gaps" syndrome, in which God is relegated to filling in the blanks of an otherwise complete scientific theory' (Isham [1997], p. 378). Likewise John Earman warns that '[t]hose who want to find God in the big bang should beware of falling into the trap of relegating God to the diminishing interstices left by modern science' (Earman [1995], p. 209). Typical worries about 'God of the gaps' apologetic arguments involve the claim that there is a long history of appeals to special divine action to explain certain phenomena, but later natural explanations for such phenomena appeared, making the appeal to special divine action unnecessary and even foolish. Making an induction over this history, one is supposed to learn the lesson not to appeal to special divine action in new cases, lest one make religion look foolish yet again when the gaps close (Saunders [2002]).

On the other hand, it has been argued recently that worries about 'God of the gaps' arguments are overstated philosophically (Ratzsch [2001]; Snoke [2001]; Larmer [2002]). Del Ratzsch notes, for example, that the argument form is valid. These worries might also be overstated historically. Are they part of the same complex of distortion as the Huxley–Draper–White thesis that the characteristic mode of interaction between science and religion has been warfare (White [1896])? This claim has been refuted by modern historians of science (Lindberg and Numbers [1986]; Brooke [1991]; Olson [2004]). The warfare thesis, a large-scale generalization, keeps company with some specific claims that are simply false, such as that the medievals believed in a flat Earth (refuted in Russell [1991]; Grant [1994]). Given how many flaws have been diagnosed in the Huxley–Draper–White story by recent historians, one might wonder whether the definitive history of God-of-the-gaps arguments also has yet to be written.

Even if one concedes that some gaps arguments for theism might not be bad arguments, it remains clear that the Big Bang singularity argument *is* a bad argument from gaps to God. That is clear from the Destroyer *reductio*: there is no nonconventional relevant difference between the Big Bang singularity and the stellar gravitational collapse, and the latter surely has no theological significance and will likely disappear due to improved physics. Here I have assumed an intolerant attitude toward singularities. If one does tolerate singularities, then every moment of the Big Bang model ($t > 0$) is preceded by earlier moments and again there is no call for extramundane explanation.

12 Fluctuating or Inaccessible Warrant

A related problem with arguing from the Big Bang to creation in time and hence theism 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 physicists are not relevant experts, though they might well write popular books and make statements to the media on such issues. 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 one's theology be affected much by the validity of Weak or Averaged Null Energy Condition assumed for singularity theorems? Many once-credible energy conditions have fallen by the wayside or are seriously threatened (Barcelo and Visser [2002]). 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 nearby (Ford and Roman [2001]; Barcelo and Visser [2002]; Ford [2003]). Nonminimally coupled classical scalar fields violate energy conditions, as does massive gravity (Visser [1998]). Are journalists, sociologists, homemakers, and truck drivers 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 belief in

God depend on which factor ordering for the Hamiltonian constraint is correct in quantum gravity? Martin Bojowald recently wrote (Bojowald [2002]):

> 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 singularity argument, must they now be able to refute Bojowald's choice of factor ordering in order to maintain that belief rationally? Even if the singularity 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. Could even the experts' judgments rationally remain stable enough to serve religious faith well? Probably not. But perhaps the choice of factor ordering is not so important after all (Date and Hossain [2005]); the fluctuations based on detailed technical premises continue.[4] If the singularity argument for theism does provide any warrant for theism, that warrant fluctuates wildly for experts and cannot be assessed by the laity.

Perhaps neither the singularity argument nor any other argument is the basis for religious faith. Craig holds to something like Reformed epistemology (private correspondence and Cowan *et al.* [2000]). Thus the religious believer does not need to read and understand every relevant paper in *Physical Review D* to maintain theistic belief rationally. Maybe this is the correct way to understand the warrant for theistic belief. But if the point of making the singularity argument is to provide an *argument* that rationally ought to persuade some people of theism, then Reformed epistemology is simply irrelevant to the task at hand. The fluctuating (for the experts) or inaccessible (for nonexperts) character of such warrant (if any) as an argument from the singularity to theism can provide, is another reason that theistic apologists ought to abandon this strategy.

[4] The point having been made, perhaps a brief explanation of the factor-ordering problem is appropriate (Komar [1979]). 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.

13 Big Bang Cosmology Not Especially Congenial to Faith

If the Big Bang singularity does not provide a good theistic argument, one might still consider whether Big Bang cosmology is somehow especially congenial to the eye of faith. Many hold that theism benefited from the victory of Big Bang cosmology over steady state cosmology. According to Francis Collins, '[t]he consequences of Big Bang theory for theology are profound. For faith traditions that describe the universe as having been created by God from nothingness (ex nihilo), this is an electrifying outcome' (Collins [2007], p. 66). As a sociological–historical claim, doubtless theism did so benefit, but is there any real philosophical advantage? Earman, noting that one can posit ideal boundary points 'at' singularities such as the Big Bang, reminds us that such boundary points are merely

> ideal elements. . . . Nothing prevents the theist from seeing God as operating at these ideal points. But since ideal points are not points of spacetime, the sense in which God can be said to cause or bring about the universe by operating at these points is very remote from the usual causal notions of science and everyday life that are concerned with connections between events in space and time. This is not to say that theistic talk about God creating the universe is illegitimate. But it is to say that such talk finds no special purchase in the big bang. *Even in models with no big bang and with time extending infinitely far into the past, ideal points corresponding to* $t = -\infty$ *could be attached to the spacetime manifold and God's helping hand could be seen at work there* (Earman [1995], p. 209; emphasis in the original).

Neither Big Bang cosmology nor some eternal-world cosmology has a beginning in the relevant sense of a first moment. Those who are willing to insist on a real first moment of (space)time, perhaps in accord with the Fourth Lateran Council, have the option of chopping off the front edge of the space-time model somewhere, whether in Big Bang cosmology or in some eternal-world cosmology, in an exercise of selective scientific antirealism. (Such a front edge presumably would be a Cauchy surface, everywhere space-like, but perhaps nearly null in places if one wishes. The question of just where to chop is vexing, however.) Along with C. J. S. Clarke (Clarke [1993], pp. 8, 9), Earman implicitly critiques such a proposal:

> Metaphysical considerations suggest that to be a serious candidate for describing actuality, a spacetime should be maximal. For example, for the Creative Force to actualize a proper subpart of a larger spacetime would seem to be a violation of Leibniz's principles of sufficient reason and plenitude. If one adopts the image of spacetime as being generated or built up as time passes then the dynamical version of the principle of

> sufficient reason would ask why the Creative Force would stop building if it is possible to continue (Earman [1995], p. 32).

On the other hand, Leibniz himself held (anachronism aside) that space-time is maximal toward the future, but it is not maximal toward the past (Alexander [1956], p. 76). God could have created the world such that events qualitatively identical to those of the first moment of the actual world would have been preceded by earlier events. 'But whether such an augmentation be reasonable and agreeable to God's wisdom, is another question, to which we answer in the negative; otherwise God would have made such an augmentation' (Alexander [1956], p. 76). Leibniz continues by quoting Horace about joining to a human head a horse's neck, a charming analogy, but not very helpful philosophically. Perhaps efficiency plays a role here in justifying nonmaximality toward the past, or perhaps the causal asymmetry or flow of time is relevant. In any case, whether one tacks on ideal beginning points, chops off the front edge of space-time to have a true first moment (and hence models space-time as a manifold with boundary), or takes a textbook space-time manifold without additions or subtractions, the 'initial' singularity and finite age of Big Bang cosmology provide no advantage over eternal universe cosmologies for theists, even when an apologetic agenda is dropped.

Given the many difficulties involved in arguing from Big Bang cosmology to creation in time, it is encouraging for theists and nontheists alike that Pope John Paul II has suggested caution in apologetic use of Big Bang cosmology:

> . . . 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 (John Paul II [1997], pp. M11, M12).

It should be noted that the concerns raised in this paper have little direct bearing on the persuasiveness of a teleological argument from cosmic fine tuning (Manson [2003]).

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