



## Beyond the Big Bang

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### THE FUNDAMENTAL QUESTION

In his biography of Ludwig Wittgenstein, Norman Malcolm reports that he said that he sometimes had a certain experience which could best be described by saying that 'when I have it, *I wonder at the existence of the world*. I am then inclined to use such phrases as 'How extraordinary that anything should exist!' or 'How extraordinary that the world should exist!' (Malcolm 1958: 56).

This mystery, which according to Aristotle lay at the very root of philosophy, [i] is one which thoughtful naturalists cannot avoid. Derek Parfit, for example, agrees that 'No question is more sublime than why there is a Universe: why there is anything rather than nothing' (Parfit 1998: 24).

As we all know, this question led G. W. Leibniz to posit the existence of a necessary being, which carries within itself the sufficient reason for its existence and which constitutes the sufficient reason for the existence of everything else in the world (Leibniz 1951: 415; 237-9). Leibniz identified this being as God. Naturalists, on the other hand, have typically claimed that the space-time universe is itself at least factually necessary - that is to say, eternal, uncaused, incorruptible, and indestructible [ii] - , while dismissing the demand for a logically necessary being. Thus, David Hume queried, 'Why may not the material universe be the necessarily existent Being . . . ?' (Hume 1947: 190). Indeed, 'How can anything, that exists from eternity, have a cause, since that relation implies a priority in time and a beginning of existence?' (Hume 1947: 190). There is no warrant for going beyond the universe to posit a supernatural ground of its existence. As Bertrand

Russell put it so succinctly in his BBC radio debate with Frederick Copleston, 'The universe is just there, and that's all' (Russell and Copleston 1964: 175).

### THE ORIGIN OF THE UNIVERSE

It was thus the presumed eternity of the universe that allowed naturalistic minds to rest comfortably in the face of the mystery of existence. This feeling of *Gemütlichkeit* was first disturbed when, in 1917, Albert Einstein made a cosmological application of his newly discovered gravitational theory, the General Theory of Relativity (GR) (Einstein 1952). In so doing he assumed that the universe is homogeneous and isotropic and that it exists in a steady state, with a constant mean mass density and a constant curvature of space. To his chagrin, however, he found that GR would not permit such a model of the universe unless he introduced into his gravitational field equations a certain 'fudge factor'  $L$  in order to counterbalance the gravitational effect of matter and so ensure a static universe. But Einstein's universe was balanced on a razor's edge, and the least perturbation would cause the universe either to implode or to expand. By taking this feature of Einstein's model seriously, the Russian mathematician Alexander Friedman and the Belgian astronomer Georges Lemaître were able to formulate independently in the 1920s solutions to the field equations which predicted an expanding universe (Friedman 1922, Lemaitre, 1927).

The monumental significance of the Friedman-Lemaître model lay in its historization of the universe. As one commentator has remarked, up to this time the idea of the expansion of the universe 'was absolutely beyond comprehension. Throughout all of human history the universe was regarded as fixed and immutable and the idea that it might actually be changing was inconceivable (Naber 1988: 126-7). But if the Friedman-Lemaître model were correct, the universe could no longer be adequately treated as a static entity existing, in effect, timelessly. Rather the universe has a history, and time will not be matter of indifference for our investigation of the cosmos.

In 1929 the astronomer Edwin Hubble showed that the red-shift in the optical spectra of light from

distant galaxies was a common feature of all measured galaxies and was proportional to their distance from us (Hubble 1929). This red-shift, first observed by Vesto Slipher in 1926, was taken to be a Doppler effect indicative of the recessional motion of the light source in the line of sight. Incredibly, what Hubble had discovered was the isotropic expansion of the universe predicted by Friedman and Lemaître on the basis of Einstein's GR. It was a veritable turning point in the history of science. 'Of all the great predictions that science has ever made over the centuries,' exclaims John Wheeler, 'was there ever one greater than this, to predict, and predict correctly, and predict against all expectation a phenomenon so fantastic as the expansion of the universe?' (Wheeler 1980: 354).

### The Standard Big Bang Model

According to the Friedman-Lemaître model, as time proceeds, the distances separating material particles become greater. It is important to understand that as a GR-based theory, the model does not describe the expansion of the material content of the universe into a pre-existing, empty, Newtonian space, but rather the expansion of space itself. The ideal particles of the cosmological fluid constituted by the matter and energy of the universe are conceived to be at rest with respect to space but to recede progressively from one another as space itself expands or stretches, just as buttons glued to the surface of a balloon would recede from one another as the balloon inflates. As the universe expands, it becomes less and less dense. This has the astonishing implication that as one reverses the expansion and extrapolates back in time, the universe becomes progressively denser until one arrives at a state of infinite density at some point in the finite past. This state represents a singularity at which space-time curvature, along with temperature, pressure, and density, becomes infinite. It therefore constitutes an edge or boundary to space-time itself. The term 'Big Bang', originally a derisive expression coined by Fred Hoyle to characterize the beginning of the universe predicted by the Friedman-Lemaître model, is thus potentially misleading, since the expansion cannot be visualized from the outside (there being no 'outside', just as there is no 'before' with respect to the Big Bang). [iii]

The standard Big Bang model, as the Friedman-

Lemaître model came to be called, thus describes a universe which is not eternal in the past, but which came into being a finite time ago. Moreover, - and this deserves underscoring- the origin it posits is an absolute origin *ex nihilo*. For not only all matter and energy, but space and time themselves come into being at the initial cosmological singularity. As Barrow and Tipler emphasize,

'At this singularity, space and time came into existence; literally nothing existed before the singularity, so, if the Universe originated at such a singularity, we would truly have a creation *ex nihilo*' (Barrow, Tipler 1986: 442). Thus, we may graphically represent space-time as a cone (Fig. 1).

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Fig. 1: Conical Representation of Standard Model Space-Time. Space and time begin at the initial cosmological singularity, before which literally nothing exists.

On such a model the universe originates *ex nihilo* in the sense that at the initial singularity it is true that *There is no earlier space-time point* or it is false that *Something existed prior to the singularity*.

Now such a conclusion is profoundly disturbing for anyone who ponders it. For the question cannot be suppressed: *Why does the universe exist rather than nothing?* Sir Arthur Eddington, contemplating the beginning of the universe, opined that the expansion of the universe was so preposterous and incredible that 'I feel almost an indignation that anyone should believe in it - except myself' (Eddington 1933: 124). He finally felt forced to conclude, 'The beginning seems to present insuperable difficulties unless we agree to look on it as frankly supernatural (Eddington 1933: 178).

Standard Big Bang cosmogony thus presents a challenge to scientific naturalism, since, in Quentin Smith's words, 'It belongs analytically to the concept of the cosmological singularity that it is not the effect of prior physical events. The definition of a singularity. . . entails that it is *impossible to extend the spacetime manifold beyond the singularity* . . . This rules out the idea

that the singularity is an effect of some prior natural process' (Smith 1993a: 120). Smith recognizes that the question which then remains is whether the Big Bang might not be plausibly regarded as the result of a supernatural cause. Otherwise, one must say that the universe simply sprang into being uncaused out of absolutely nothing. Thus, in the words of one astrophysical team, 'The problem of the origin involves a certain metaphysical aspect which may be either appealing or revolting' (Reeves, Audouze, Fowler and Schramm 1973: 912)

### The Steady State Model

Revolted by the stark metaphysical alternatives presented by an absolute beginning of the universe, naturalists have been understandably eager to subvert the Standard Model and restore an eternal universe. Sir Fred Hoyle, for example, could countenance neither an uncaused nor a supernaturally caused origin of the universe. With respect to the singularity, he wrote, 'This most peculiar situation is taken by many astronomers to represent *the origin of the universe*. The universe is supposed to have begun at this particular time. From where? The usual answer, surely an unsatisfactory one, is: from nothing!' (Hoyle 1975a: 165). Equally unsatisfactory was the postulation of a supernatural cause. Noting that some accept happily the universe's absolute beginning, Hoyle complained,

To many people this thought process seems highly satisfactory because a 'something' outside physics can then be introduced at  $t = 0$ . By a semantic manoeuvre, the word 'something' is then replaced by 'god,' except that the first letter becomes a capital, God, in order to warn us that we must not carry the enquiry any further' (Hoyle 1975b: 658).

To Hoyle's credit, he did carry the inquiry further by helping to formulate the first competitor to the Standard Model. In 1948 Hoyle, together with Hermann Bondi and Thomas Gold, broached the Steady State Model of the universe (Bondi and Gold 1948; Hoyle 1948). According to this theory, the universe is in a state of isotropic cosmic expansion, but as the galaxies recede, new matter is drawn into being *ex nihilo* in the interstices of space created by the galactic recession (Fig. 2).

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Fig. 2: Steady State Model. As the galaxies mutually recede, new matter comes into existence to replace them. The universe thus constantly renews itself and so never began to exist.

The expansion of the universe in the Steady State Model can be compared to a rubber sheet with buttons glued to it: as the sheet is stretched and the buttons separate, new buttons come into being in the voids created by the recession of the previously existing buttons. Thus, the condition of the sheet remains constant over time, and no beginning of the process need be posited. If one extrapolates the expansion of the universe back in time, the density of the universe never increases because the matter and energy simply vanish as the galaxies mutually approach!

The Steady State theory never secured a single piece of experimental verification; its appeal was purely metaphysical. [iv] The discovery of progressively more radio galaxies at ever greater distances undermined the theory by showing that in the past the universe was significantly different than it is today, thus contradicting the notion of a steady state of the universe. Instead it became increasingly evident that the universe had an evolutionary history. But the decisive refutation of the Steady State Model came with two discoveries which constituted, in addition to the galactic red-shift, the most significant evidence for the Big Bang theory: the cosmogonic nucleosynthesis of the light elements and the microwave background radiation. Although the heavy elements were synthesized in the stellar furnaces, stellar nucleosynthesis could not manufacture the abundant light elements such as helium and deuterium. These could only have been created in the extreme conditions present in the first moment of the Big Bang. In 1965 a serendipitous discovery revealed the existence of a cosmic background radiation predicted in the 1940s by George Gamow on the basis of the Standard Model. This radiation, now shifted into the microwave region of the spectrum, consists of photons emitted during a very hot and dense phase of the universe. In the minds of almost all cosmologists, the cosmic background radiation decisively discredited the Steady State Model.

### Oscillating Models

The Standard Model was based on the assumptions of homogeneity and isotropy. In the 1960s and '70s some cosmologists suggested that by denying homogeneity and isotropy, one might be able to craft an Oscillating Model of the universe and thus avert the absolute beginning predicted by the Standard Model (Lifschitz and Khalatnikov 1963: 207). If the internal gravitational pull of the mass of the universe were able to overcome the force of its expansion, then the expansion could be reversed into a cosmic contraction, a Big Crunch. If the universe were not homogeneous and isotropic, then the collapsing universe might not coalesce at a point, but the material contents of the universe might pass by one another, so that the universe would appear to bounce back from the contraction into a new expansion phase. If this process could be repeated indefinitely, then an absolute beginning of the universe might be avoided (Fig. 3).

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Fig. 3: Oscillating Model. Each expansion phase is preceded and succeeded by a contraction phase, so that the universe in concertina-like fashion exists without beginning or end.

Such a theory is extraordinarily speculative, but again there were metaphysical motivations for adopting this model. [v] The prospects of the Oscillating Model were severely dimmed in 1970, however, by Roger Penrose and Stephen Hawking's formulation of the Singularity Theorems which bear their names (Penrose 1965: 57-9; Hawking and Penrose 1973: 266). The theorems disclosed that under very generalized conditions an initial cosmological singularity is inevitable, even for inhomogeneous and non-isotropic universes. Reflecting on the impact of this discovery, Hawking notes that the Hawking-Penrose Singularity Theorems 'led to the abandonment of attempts (mainly by the Russians) to argue that there was a previous contracting phase and a non-singular bounce into expansion. Instead almost everyone now believes that the universe, and time itself, had a beginning at the big bang' (Hawking and Penrose 1996: 20).

Despite the fact that no space-time trajectory can be extended through a singularity, the Oscillating Model exhibited a stubborn persistence. Three further strikes were lodged against it. First, there

are no known physics which would cause a collapsing universe to bounce back to a new expansion. If, in defiance of the Hawking--Penrose Singularity Theorems, the universe rebounds, this is predicated upon a physics which is completely unknown. Physics predicts that a universe in a state of gravitational self-collapse will not rebound like a basketball dropped to the floor, but rather land like a lump of clay (Guth and Sher 1983: 505-06; Bludman 1984: 319-22). Second, the observational evidence indicates that the mean mass density of the universe is insufficient to generate enough gravitational attraction to halt and reverse the expansion. Tests employing a variety of techniques for measuring the density of the universe and the deceleration of the expansion continue to point to a density below the critical value. In January of 1998 astronomical teams from Princeton, Yale, the Lawrence Berkeley National Laboratory, and the Harvard-Smithsonian Astrophysics Institute reported at the American Astronomical Society meeting that their various tests all show that 'the universe will expand forever'. [vii] This effectively rules out an oscillating universe. Third, the thermodynamic properties of an Oscillating Model imply the very beginning its proponents sought to avoid. Entropy increases from cycle to cycle in such a model, which has the effect of generating larger and longer oscillations with each successive cycle (Fig. 4).

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Fig. 4: Oscillating Model with Entropy Increase. Due to the conservation of entropy each successive oscillation has a larger radius and longer expansion time.

Thus, as one traces the oscillations back in time, they become progressively smaller until one reaches a first and smallest oscillation. Zeldovich and Novikov conclude, 'The multicycle model has an infinite future, but only a finite past' (Novikov and Zeldovich 1973: 401-2). In fact, astronomer Joseph Silk estimates on the basis of current entropy levels that the universe cannot have gone through more than 100 previous oscillations (Silk 1989: 311-12). Even if this difficulty were avoided (Hochberg, Molina-Paris and Visser 1999), a universe oscillating from eternity past would require an infinitely precise tuning of initial conditions in order to perdure through an infinite

number of successive bounces. A universe rebounding from a single, infinitely long contraction is, if entropy increases during the contracting phase, thermodynamically untenable and incompatible with the initial low entropy condition of our expanding phase; postulating an entropy decrease during the contracting phase in order to escape this problem would require us to postulate inexplicably special low entropy conditions at the time of the bounce in the life of an infinitely evolving universe. Such a low entropy condition at the beginning of the expansion is more plausibly accounted for by the presence of a singularity or some sort of quantum creation event.

Although these difficulties were well-known, proponents of the Oscillating Model tenaciously clung to it until a new alternative to the Standard Model emerged during the 1970s. [viii] Looking back, quantum cosmologist Christopher Isham muses;

“Perhaps the best argument in favor 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, such as continuous creation or an oscillating universe, 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 1988: 378).

The Oscillating Model drew its life from its avoidance of an absolute beginning of the universe; but once other models became available claiming to offer the same benefit, the Oscillating Model sank into oblivion under the weight of its own deficiencies.

### Vacuum Fluctuation Models

It was realized that a physical description of the universe prior to the Planck time (10<sup>-43</sup> second after the Big Bang singularity) would require the introduction of quantum physics in addition to GR. On the quantum level so-called virtual particles are thought to arise due to fluctuations in the energy locked up in the vacuum, particles which the Heisenberg Indeterminacy Principle allows to exist for a fleeting moment before dissolving back into the vacuum. In 1973 Edward Tryon

speculated whether the universe might not be a long-lived virtual particle, whose total energy is zero, born out of the primordial vacuum (Tryon 1973: 396-7). This seemingly bizarre speculation gave rise to a new generation of cosmogonic theories which we may call Vacuum Fluctuation Models. These models were closely related to an adjustment to the Standard Model known as Inflation. In an attempt to explain - or explain away, depending on one's viewpoint - the astonishing large-scale homogeneity and isotropy of the universe, certain theorists proposed that between 10<sup>-35</sup> and 10<sup>-33</sup> sec after the Big Bang singularity, the universe underwent a phase of super-rapid, or inflationary, expansion which served to push the inhomogeneities out beyond our event horizon (Guth 1981). Prior to the Inflationary Era the universe was merely empty space, or a vacuum, and the material universe was born when the vacuum energy was converted into matter via a quantum mechanical phase transition. In most inflationary models, as one extrapolates backward in time, beyond the Planck time, the universe continues to shrink down to the initial singularity. But in Vacuum Fluctuation Models, it is hypothesized that prior to inflation the Universe-as-a-whole was not expanding. This Universe-as-a-whole is a primordial vacuum which exists eternally in a steady state. Throughout this vacuum sub-atomic energy fluctuations constantly occur, by means of which matter is created and mini-universes are born (Fig. 5).

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Fig. 5: Vacuum Fluctuation Models. Within the vacuum of the wider Universe, fluctuations occur which grow into mini-universes. Ours is but one of these, and its relative beginning does not imply a beginning for the Universe-as-a-whole.

Our expanding universe is but one of an indefinite number of mini-universes conceived within the womb of the greater Universe-as-a-whole. Thus, the beginning of our universe does not represent an absolute beginning, but merely a change in the eternal, uncaused Universe-as-a-whole.

Though still bandied about in the popular press, Vacuum Fluctuation Models did not outlive the decade of the 1980s. Not only were there

theoretical problems with the production mechanisms of matter, but these models faced a deep internal incoherence (Isham 1988: 385-7). According to such models, it is impossible to specify precisely when and where a fluctuation will occur in the primordial vacuum which will then grow into a universe. Within any finite interval of time there is a positive probability of such a fluctuation occurring at any point in space. Thus, given infinite past time, universes will eventually be spawned at every point in the primordial vacuum, and, as they expand, they will begin to collide and coalesce with one another. Thus, given infinite past time, we should by now be observing an infinitely old universe, not a relatively young one. One theorist tries to avoid this problem by stipulating that fluctuations in the primordial vacuum only occur infinitely far apart, so that each mini--universe has infinite room in which to expand (Gott 1982: 304-7). Not only is such a scenario unacceptably *ad hoc*, but it does not even solve the problem. For given infinite past time, each of the infinite regions of the vacuum will have spawned an open universe which by now will have entirely filled that region, with the result that all of the individual mini-universes would have coalesced.

Isham has called this problem 'fairly lethal' to Vacuum Fluctuation Models and says that therefore they 'have not found wide acceptance' (Isham 1990). About the only way to avert the problem would be to postulate an expansion of the primordial vacuum itself; but then we are right back to the absolute origin implied by the Standard Model. According to Isham these models were therefore 'jettisoned twenty years ago' and 'nothing much' has been done with them since (Isham 1994).

### Chaotic Inflationary Model

Inflation also forms the context for the next alternative we shall consider: the Chaotic Inflationary Model. Inflationary theory has not only been criticized as unduly 'metaphysical,' but has also been crippled by various physical problems (such as getting inflation to transition to the current expansion). We have seen the Old Inflationary Theory and the New Inflationary Theory, both of which are now dead. One of the most fertile of the inflation theorists has been the Russian cosmologist Andrei Linde, who currently champions his Chaotic Inflationary Model (Linde

1984, 1983). According to cosmologist Robert Brandenberger, 'Linde's chaotic inflation scenario is . . . the only viable inflationary model in the sense that it is not plagued with internal inconsistencies (as "old inflation" and "new inflation" are)'. [ix] In Linde's model inflation *never* ends: each inflating domain of the universe when it reaches a certain volume gives rise via inflation to another domain, and so on, *ad infinitum* (Fig. 6).

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Fig. 6: Chaotic Inflationary Model. The wider universe produces via inflation separate domains which continue to recede from one another as the wider space expands.

Linde's model thus has an infinite future. But Linde is troubled at the prospect of an absolute beginning. He writes, 'The most difficult aspect of this problem is not the existence of the singularity itself, but the question of what was *before* the singularity . . . This problem lies somewhere at the boundary between physics and metaphysics' (Linde 1984: 976). Linde therefore proposes that chaotic inflation is not only endless, but beginningless. Every domain in the universe is the product of inflation in another domain, so that the singularity is averted and with it as well the question of what came before (or, more accurately, what caused it).

In 1994, however, Arvind Borde and Alexander Vilenkin showed that a universe eternally inflating toward the future cannot be geodesically complete in the past, that is to say, there must have existed at some point in the indefinite past an initial singularity. They write,

A model in which the inflationary phase has no end . . . naturally leads to this question: Can this model also be extended to the infinite past, avoiding in this way the problem of the initial singularity?

. . . this is in fact not possible in future--eternal inflationary spacetimes as long as they obey some reasonable physical conditions: such models must necessarily possess initial singularities.

. . . the fact that inflationary spacetimes are past incomplete forces one to address the question of

what, if anything, came before (Borde and Vilenkin 1994: 3305, 3307).

In his response, Linde concurs with the conclusion of Borde and Vilenkin: there must have been a Big Bang singularity at some point in the past (Linde, A, Linde, D. and Mezhlumian 1994). Therefore, inflationary models, like their predecessors, failed to avert the beginning predicted by the Standard Model.

### Quantum Gravity Models

At the close of their analysis of Linde's Chaotic Inflationary Model, Borde and Vilenkin say with respect to Linde's metaphysical question, 'The most promising way to deal with this problem is probably to treat the Universe quantum mechanically and describe it by a wave function rather than by a classical spacetime' (Borde and Vilenkin 1994: 3307). They thereby allude to the next class of models which we shall discuss, namely, Quantum Gravity Models. Vilenkin and, more famously, James Hartle and Stephen Hawking have proposed models of the universe which Vilenkin candidly calls exercises in 'metaphysical cosmology'. [x] In his best-selling popularization of his theory, Hawking even reveals an explicitly theological orientation. He concedes that on the Standard Model one could legitimately identify the Big Bang singularity as the instant at which God created the universe (Hawking 1988: 9). Indeed, he thinks that a number of attempts to avoid the Big Bang were probably motivated by the feeling that a beginning of time 'smacks of divine intervention' (Hawking 1988: 46). He sees his own model as preferable to the Standard Model because there would be no edge of space-time at which one 'would have to appeal to God or some new law'(Hawking 1988: 136). As we shall see, he is not at all reluctant to draw theological conclusions on the basis of his model.

Both the Hartle-Hawking and the Vilenkin models eliminate the initial singularity by transforming the conical hyper-surface of classical space--time into a smooth, curved hyper--surface having no edge (Fig. 7).

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Fig. 7: Quantum Gravity Model. In the Hartle-Hawking version, space--time is 'rounded off' prior

to the Planck time, so that although the past is finite, there is no edge or beginning point.

This is accomplished by the introduction of imaginary numbers for the time variable in Einstein's gravitational equations, which effectively eliminates the singularity. Hawking sees profound theological implications in the model:

The idea that space and time may form a closed surface without boundary . . . has profound implications for the role of God in the affairs of the universe . . . .So long as the universe had a beginning, we could suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end. What place, then, for a creator? (Hawking 1988: 140-1).

Hawking does not deny the existence of God, but he does think his model eliminates the need for a Creator of the universe.

The key to assessing this theological claim is the physical interpretation of Quantum Gravity Models. By positing a finite (imaginary) time on a closed surface prior the Planck time rather than an infinite time on an open surface, such models actually seem to support, rather than undercut, the idea that time had a beginning. Such theories, if successful, enable us to model the beginning of the universe without an initial singularity involving infinite density, temperature, pressure, and so on. As Barrow points out, 'This type of quantum universe has not always existed; it comes into being just as the classical cosmologies could, but it does not start at a Big Bang where physical quantities are infinite . . .' (Barrow 1991: 68). Barrow points out that such models are 'often described as giving a picture of "creation out of nothing," ' the only caveat being that in this case 'there is no definite . . . point of creation' (Barrow 1991: 67-8). Hartle-Hawking themselves construe their model as giving 'the amplitude for the Universe to appear from nothing,' and Hawking has asserted that according to the model the universe 'would quite literally be created out of nothing: not just out of the vacuum, but out of absolutely nothing at all, because there is nothing outside the universe' (Hartle and Hawking 1983: 2961; Hawking and Penrose 1996: 85). Similarly, Vilenkin claims that his model describes the creation of the universe 'from literally *nothing*'

(Vilenkin 1982: 26). Taken at face value, these statements entail the beginning of the universe. Hence, Hawking means to include himself when he asserts that 'almost everyone now believes that the universe, and time itself, had a beginning at the Big Bang' (Hawking and Penrose 1996: 20). Hawking's statement quoted above concerning the theological implications of his model must therefore be understood to mean that on such models there are no beginning or ending *points*. But having a beginning does not entail having a beginning point. Even in the Standard Model, theorists sometimes 'cut out' the initial singular point without thinking that therefore space-time no longer begins to exist and the problem of the origin of the universe is thereby resolved. Time begins to exist just in case for any finite temporal interval, there are only a finite number of equal temporal intervals earlier than it. That condition is fulfilled for Quantum Gravity Models as well as for the Standard Model. Nor should we think that by giving the amplitude for the universe to appear from nothing quantum cosmologists have eliminated the need for a Creator, for that probability is conditional upon several choices which only the Creator could make (such as selecting the wave function of the universe) and is dubiously applied to absolute nothingness. [xi] Thus, Quantum Gravity models, like the Standard Model, imply the beginning of the universe.

Perhaps it will be said that such an interpretation of Quantum Gravity Models fails to take seriously the notion of 'imaginary time.' Introducing imaginary numbers for the time variable in Einstein's equation has the peculiar effect of making the time dimension indistinguishable from space. But in that case, the imaginary time regime prior to the Planck time is not a space-time at all, but a Euclidean four-dimensional space. Construed realistically, such a four-space would be evacuated of all temporal becoming and would simply exist timelessly. Thus, Vilenkin characterizes this regime as a 'state in which all our basic notions of space, time, energy, entropy, etc. lose their meaning' (Vilenkin 1983: 2851). Hawking describes it as 'completely self-contained and not affected by anything outside itself. It would be neither created nor destroyed. It would just BE' (Hawking 1988: 136).

The question which arises for this construal of the model is whether such an interpretation is meant to

be taken realistically or instrumentally. On this score, there can be little doubt that the use of imaginary quantities for time is a mere mathematical device without ontological significance. For, first, there is no intelligible physical interpretation of imaginary time on offer. What, for example, would it mean to speak of the lapse of an imaginary second or of a physical object's enduring through two imaginary minutes? Second, time is metaphysically distinct from space, its moments being ordered by an *earlier than* relation which does not similarly order points in space. But this essential difference is obscured by imaginary time. Thus, 'imaginary time' is most plausibly construed as a mathematical *Hilfsmittel*. Barrow observes, physicists have often carried out this 'change time into space' procedure as a useful trick for doing certain problems in ordinary quantum mechanics, although they did not imagine that time was *really* like space. At the end of the calculation, they just swapback into the usual interpretation of there being one dimension of time and three . . . dimensions of . . . space (Barrow 1991: 66-7).

In his model, Hawking simply declines to re-convert to real numbers. If we do, then the singularity re--appears. Hawking admits, 'Only if we could picture the universe in terms of imaginary time would there be no singularities . . . When one goes back to the real time in which we live, however, there will still appear to be singularities' (Hawking 1988: 138-9). Hawking's model is thus a way of re-describing a universe with a singular beginning point in such a way that that singularity is transformed away; but such a re-description is not realist in character.

Remarkably, Hawking has more recently stated explicitly that he interprets the Hartle-Hawking Model non-realistically. He confesses, 'I'm a positivist . . . I don't demand that a theory correspond to reality because I don't know what it is' (Hawking and Penrose 1996: 121). Still more extreme, 'I take the positivist view point that a physical theory is just a mathematical model and that it is meaningless to ask whether it corresponds to reality'. [xiii] The clearest example of Hawking's instrumentalism is his combination of an electron quantum tunneling in Euclidean space (with time being imaginary) and an electron/positron pair accelerating away from each other in Minkowski space-time (Hawking

and Penrose 1996: 53-5). This analysis is directly analogous to the Hartle--Hawking cosmological model; and yet no one would construe particle pair creation as literally the result of an electron transitioning out of a timelessly existing four--space into our classical space--time. It is just an alternative description employing imaginary numbers rather than real numbers.

Significantly, the use of imaginary quantities for time is an inherent feature of *all* Quantum Gravity Models. [xiv] This precludes their being construed realistically as accounts of the origin of the space--time universe in a timelessly existing four--space. Rather they are ways of modeling the real beginning of the universe *ex nihilo* in such a way as to not involve a singularity. What brought the universe into being remains unexplained on such accounts.

Moreover, we are not without positive reasons for affirming the reality of the singular origin of space-time postulated by the Standard Model. John Barrow has rightly cautioned that 'one should be wary of the fact that many of the studies of quantum cosmology are motivated by the desire to avoid an initial singularity of infinite density, so they tend to focus on quantum cosmologies that avoid a singularity at the expense of those that might contain one' (Barrow 1994: 113). Noting the same tendency, Roger Penrose states, 'I have gradually come around to the view that it is actually misguided to ask that the space-time singularities of classical relativity should disappear when standard techniques of quantum (field) theory are applied to them' (Penrose 1982: 4). For if the initial cosmological singularity is removed, then 'we should have lost what seems to me to be the best chance we have of explaining the mystery of the second law of thermodynamics' (Penrose 1982: 5). What Penrose has in mind is the remarkable fact that as one goes back in time the entropy of the universe steadily decreases. Just how unusual this is can be demonstrated by means of the Bekenstein--Hawking formula for the entropy of a stationary black hole. The total observed entropy of the universe is 1088. Since there are around 1080 baryons in the universe, the observed entropy per baryon must be regarded as extremely small. By contrast in a collapsing universe the entropy would be 10123 near the end. Comparison of these two numbers reveals how absurdly small 1088 is compared to

what it might have been. Thus, the structure of the Big Bang must have been severely constrained in order that thermodynamics as we know it should have arisen. So how is this special initial condition to be explained? According to Penrose, we need the initial cosmological singularity, conjoined with the Weyl Curvature Hypothesis, according to which initial singularities (as opposed to final singularities) must have vanishing Weyl curvature. [xv] In standard models, the Big Bang does possess vanishing Weyl curvature. The geometrical constraints on the initial geometry have the effect of producing a state of very low entropy. So the entropy in the gravitational field starts at zero at the Big Bang and gradually increases through gravitational clumping. The Weyl Curvature Hypothesis thus has the time asymmetric character necessary to explain the second law. By contrast, the Hartle--Hawking model 'is very far from being an explanation of the fact that past singularities have small Weyl curvature whereas future singularities have large Weyl curvature' (Hawking and Penrose 1996: 129). On Hawking's time symmetrical theory, we should have white holes spewing out material, in contradiction to the Weyl Curvature Hypothesis, the Second Law of Thermodynamics, and probably also observation (Hawking and Penrose 1996: 130). Penrose supplies the following figure to illustrate the difference:

SORRY THE PICTURE IS COMING SOON!

Fig. 8. Contrast between the universe as we know it (assumed for convenience to be closed) with a more probable universe. In both cases the Big Crunch is a high entropy (~10123), complicated, unconstrained singularity. For the left-hand picture the Big Bang is a low entropy (<1088), highly constrained, initial singularity, while for the right-hand picture it is an unconstrained, much more probable Big Bang. The 'stalactites' represent singularities of black holes, while the 'stalagmites' represent singularities of white holes.

If we remove the initial cosmological singularity, we render the Weyl Curvature Hypothesis irrelevant and 'we should be back where we were in our attempts to understand the origin of the second law' (Penrose 1982: 5). Could the special initial geometry have arisen purely by chance in the absence of a cosmic singularity? Penrose's answer is decisive: 'Had there not been any

constraining principles (such as the Weyl curvature hypothesis) the Bekenstein--Hawking formula would tell us that the probability of such a "special" geometry arising by chance is at least as small as about one part in  $10^{1000} B^{3/2}$  where  $B$  is the present baryon number of the universe [ $\sim 10^{80}$ ] (Penrose 1982: 5). Thus Penrose calculates that, aiming at a phase space whose regions represent the likelihood of various possible configurations of the universe, 'the accuracy of the Creator's aim' would have to have been one part in  $10^{10^{123}}$  in order for our universe to exist (Penrose 1981: 249; cf. Hawking and Penrose 1996: 34-5). He comments, 'I cannot even recall seeing anything else in physics whose accuracy is known to approach, even remotely, a figure like one part in  $10^{10^{123}}$ ' (Penrose 1981: 249).

Thus, the initial cosmological singularity may be a virtual thermodynamical necessity. But whether it was at a singular point or not, the fact that the universe began to exist remains a prediction of any realistic interpretation of Quantum Gravity models.

### Ekpyrotic Models

We come finally to the extreme edge of cosmological speculation: string cosmology. These models are based on an alternative to the standard quark model of elementary particle physics. So-called string theory (or M-theory) conceives of the fundamental building blocks of matter to be, not particles like quarks, but tiny vibrating strings of energy. String theory is so complicated and embryonic in its development that all its equations have not yet even been stated, much less solved. But that has not deterred some cosmologists from trying to craft cosmological models based on concepts of string theory to try to avert the beginning predicted by standard Big Bang cosmology.

The most celebrated of these scenarios in the popular press has been the so-called ekpyrotic scenario championed by Paul Steinhardt. [xvi] In the most recent revision, the cyclic ekpyrotic model, we are asked to envision two three-dimensional membranes (or 'branes' for short) existing in a five-dimensional space-time (Fig. 9). One of these branes is our universe. These two branes are said to be in an eternal cycle in which they approach each other, collide, and retreat

again from each other. It is the collision of the other brane with ours that causes the expansion of our universe. With each collision, the expansion is renewed. Thus, even though our three-dimensional universe is expanding, it never had a beginning.

SORRY THE PICTURE IS COMING SOON!

Fig. 9: Two three-dimensional membranes in an eternal cycle of approach, collision, and retreat. With each collision the expansion of our universe is re-invigorated.

Now apart from its speculative nature the ekpyrotic scenario is plagued with problems. [xvii] For example, the Horava-Witten version of string theory on which the scenario is based requires that the brane on which we live have a positive tension. But in the ekpyrotic scenario it has a negative tension in contradiction to the theory. Attempts to rectify this have been unsuccessful. Second, the model requires an extraordinary amount of *ad hoc* fine tuning. For example, the two branes have to be so perfectly aligned that even at a distance of  $10^{30}$  greater than the space between them, they cannot deviate from being parallel by more than  $10^{-60}$ . There is no explanation at all for this extraordinary setup. Third, the collapsing and retreating branes are the equivalent of a 4-D universe which goes through an eternal cycle of contractions and expansions. In this sense, the cyclic ekpyrotic model is just the old oscillating model writ large in five dimensions. As such, it faces exactly the same problem as the original: there is no way for the universe to pass through a singularity at the end of each cycle to begin a new cycle and no physics to cause a non-singular bounce. Finally, even if the branes could bounce back, there is no means of the physical information in one cycle being carried through to the next cycle, so that the ekpyrotic scenario has been unable to deliver on its promises to explain the large-scale structure of the observable universe. These are just some of the problems afflicting the model. It is no wonder that Andrei Linde has recently complained that while the cyclic ekpyrotic scenario is 'very popular among journalists,' it has remained 'rather unpopular among scientists' (Linde 2002: 8).

But let all that pass. Perhaps all these problems can be somehow solved. The more important

point is that it turns out that, like the chaotic inflationary model, the cyclic ekpyrotic scenario cannot be eternal in the past. In September of 2001 Borde and Vilenkin, in cooperation with Alan Guth, were able to generalize their earlier results on inflationary models in such a way to extend their conclusion to other models. Specifically, they note, 'Our argument can be straightforwardly extended to cosmology in higher dimensions,' specifically brane--cosmology. [xix] that is to say, the need for an initial singularity has not been eliminated. Therefore, such a universe cannot be past-eternal.

## Summary

With each successive failure of alternative cosmogonic theories to avoid the absolute beginning of the universe predicted by the Standard Model, that prediction has been corroborated. This beginning of the universe, of space and time themselves, reveals the contingency of the universe. The universe is evidently not necessarily existent, as Hume suggested, since it is not eternal, and therefore its existence does cry out for explanation. It is no longer sufficient to dismiss this problem with a shrug and a slogan, 'The universe is just there, and that's all.'

Of course, in view of the metaphysical issues raised by the prospect of a beginning of the universe, we may be confident that the quest to avert such a beginning will continue unabated. [xx] Such efforts are to be encouraged, and we have no reason to think that such attempts at falsification will result in anything other than further corroboration of the prediction of a beginning. In the meantime, the beginning cannot be wished away. Given its origin *ex nihilo*, the demand why the universe exists rather than nothing presses insistently upon us.

## BEYOND THE BIG BANG

### The Alternatives before Us

The discovery that the universe is not eternal but had a beginning implies that the universe is not necessary in its existence and therefore has its ground in a transcendent being. The only way of avoiding this conclusion would be to deny Leibniz's conviction that whatever exists has a reason for its existence, either in the necessity of

its own nature or else in an external ground, and to claim that the universe simply sprang into being uncaused out of nothing. Reflecting upon the current situation, P. C. W. Davies muses,

What caused the big bang?' . . . One might consider some supernatural force, some agency beyond space and time as being responsible for the big bang, or one might prefer to regard the big bang as an event without a cause. It seems to me that we don't have too much choice. Either . . . something outside of the physical world . . . or . . . an event without a cause (Davies 1995: 8-9).

J. Richard Gott and Li-Xin Li seek to break this dilemma by defending the extraordinary hypothesis that *the universe created itself*. Observing that 'The question of first-cause has been troubling to philosophers and scientists alike for over two thousand years,' they note that modern scientists have, like Aristotle, found models of the universe attractive which involve the universe's sempiternal existence, since in this way 'one would not have to ask what caused it to come into being' (Gott and Li -Xin 1998: 023501-1). 'Now that it is apparent that our universe began in a big bang explosion', however, 'models with a finite beginning have taken precedence' and 'the question of what happened before the big bang arises' (Gott and Li-Xin 1998: 023501-1). They observe that inflation seemed to be 'a very promising answer, but as Borde and Vilenkin have shown, the inflationary state preceding the big bang could not have been infinite in duration - it must have had a beginning also. Where did it come from? Ultimately, the difficult question seems to be how to make something out of nothing' (Gott and Li-Xin 1998: 023501-1). Gott and Li-Xin, however, suggest instead that we should ask whether anything in the laws of physics would prevent the universe from creating itself.

Noting that General Relativity allows for the possibility of closed time--like curves, they hypothesize that as we trace the history of the universe back through an original inflationary state, we encounter a region of closed time--like curves prior to inflation. According to one possible scenario, a metastable vacuum inflates, producing an infinite number of (Big Bang type) bubble universes. In many of these a number of bubbles of metastable vacuum are created at late

times by high energy events. These bubbles usually collapse and form black holes, but occasionally one will tunnel to create an expanding, metastable vacuum or baby universe. One of these expanding, metastable vacuum baby universes 'turns out to be the original inflating metastable vacuum we began with' (Fig. 9).

SORRY THE PICTURE IS COMING SOON!

Fig. 9: A self-creating universe. Four inflating baby universes are shown. Universes A and D have not created any baby universes. Universe C has created universe D. Universe B has created three universes: A, C, and itself, B. The torus-shaped region at the bottom is a region of closed time-like curves. Such a universe neither arose from a singularity nor tunneled from nothing, but it created itself.

Gott and Li-Xin conclude that 'the laws of physics may allow the universe to be its own mother' (Gott and Li-Xin 1998: 023501-1).

Now we may leave it to the physicists to assess Gott and Li-Xin's claim that the laws of physics permit such a scenario, as well as the question of whether there are non-lawlike physical facts which contradict it. For the Gott-Li-Xin hypothesis raises fundamental metaphysical issues about the nature of time which, I think, render their hypothesis either metaphysically impossible or else superfluous.

Philosophers of time have distinguished two different views about the nature of time, which have been called the A-- and the B--theories of time respectively. [xxi] According to the A--theory, temporal moments may be classed as past, present, and future, and only that moment which is present exists. Past moments and the things or events which occupy them have passed away and no longer exist; future moments, things, and events have not yet come to be and so do not yet exist. On the A--theory of time things come into and go out of being, and thus temporal becoming is a real and objective feature of reality.

By contrast, on the B--theory of time the distinction between past, present, and future is a subjective illusion of human consciousness. All things or events in time are equally real and

existent, and moments, things, and events merely stand to one another in tenseless relations of *earlier than*, *simultaneous with*, or *later than*. Nothing ever comes into or goes out of being, and temporal becoming is an illusion.

Now all instances of causal influence over the past - whether we are talking about closed time--like curves, time travel, retro--causation, tachyonic anti-telephones, or whatever - presuppose the truth of the B--theory of time. [xxii] For clearly on the A--theory of time, at the time at which the effect is present, the cause is future and therefore literally non-existent. Thus, the effect just comes into being from nothing. Not only does this scenario seem absurd, but it also reduces to the first horn of Davies' dilemma with respect to the origin of the universe. The universe just came uncaused from nothing.

Thus the Gott-Li-Xin hypothesis presupposes the B--theory of time. But if one presupposes such a view of time, then Gott and Li-Xin's hypothesis becomes superfluous. For on a B--theory of time the universe never truly comes into being at all. [xxiii] The whole four-dimensional spacetime manifold just exists tenselessly, and the universe has a beginning only in the sense that a meter-stick has a beginning prior to the first centimeter. Although the spacetime manifold is intrinsically temporal in that one of its four dimensions is time, nonetheless it is extrinsically timeless, in that it does not exist in an embedding hyper-time but exists tenselessly, neither coming into nor going out of being. The four-dimensional spacetime manifold is in this latter sense eternal. Thus, there is no need for the device of causal loops or closed time-like curves at the beginning to explain how it came into being.

Now space does not permit me to review the arguments for and against the A-- and B--theories of time. I have explored this fascinating debate for the last dozen years and report my findings elsewhere. [xxiv] Here I can only outline my reasons for affirming an A--theory of time as the most plausible view of the matter:

## I. Arguments for the A--Theory

A. Linguistic tense, which is ineliminable and irreducible, mirrors the tensed facts which are characteristic of reality. [xxv]

B. The experience of temporal becoming, like our experience of the external world, should be regarded as veridical. [xxvi]

## II. Refutation of Arguments against the A--Theory

A. McTaggart's Paradox is based upon the illicit assumption that there should exist a unique tenseless description of reality, as well as the illicit conflation of A--theoretic becoming with a B--theoretic ontology. [xxvii]

B. The passage of time is not a myth, but a metaphor for the objectivity of temporal becoming, a notion which can be consistently explicated on a presentist metaphysic. [xxviii]

## III. Refutation of Arguments for the B--Theory

A. Temporal becoming is wholly compatible with the mathematical core of Relativity Theory, even if its affirmation requires a different physical interpretation than the received view. [xxix]

B. Time, as it plays a role in physics, is an abstraction of a richer metaphysical reality, omitting indexical elements such as the 'here' and the 'now' in the interest of universalizing the formulations of natural laws. [xxx]

## IV. Arguments against the B--Theory

A. In the absence of objective distinctions between past, present, and future, the relations ordering events on the B--theory are only gratuitously regarded as genuinely temporal relations of *earlier/later than*. [xxxi]

B. The subjective illusion of temporal becoming involves itself an objective temporal becoming of contents of consciousness. [xxxii]

C. The B--theory entails perdurantism, the view that objects have spatio-temporal parts, a doctrine which is metaphysically counter-intuitive, incompatible with moral accountability, and entails the bizarre counterpart theory of transworld identity. [xxxiii]

Given the truth of the A--theory of time, the idea that the universe is self-created, that is to say, brought itself into being via closed timelike

curves, is either metaphysically impossible or else reduces to the notion that the universe sprang into existence uncaused out of nothing. Thus, I think that we are stuck with Davies' dilemma: the beginning of the universe is either an event without a cause or it is the result of a supernatural agency.

### The Supernaturalist Alternative

Suppose we go the route of postulating some causal agency beyond space and time as being responsible for the origin of the universe. A conceptual analysis of what properties must be possessed by such an ultra-mundane cause enables us to recover a striking number of the traditional divine attributes. For as the cause of space and time, this entity must transcend space and time and therefore exist atemporally and non-spatially, at least sans the universe. This transcendent cause must therefore be changeless and immaterial, since timelessness entails changelessness, and changelessness implies immateriality. Such a cause must be beginningless and uncaused, at least in the sense of lacking any antecedent causal conditions. Ockham's Razor will shave away further causes, since we should not multiply causes beyond necessity. This entity must be unimaginably powerful, since it created the universe out of nothing.

Finally, and most strikingly, such a transcendent cause is plausibly to be regarded as personal. As Swinburne points out, there are two types of causal explanation: scientific explanations in terms of laws and initial conditions and personal explanations in terms of agents and their volitions (Swinburne 1991: 32-48). A first state of the universe cannot have a scientific explanation, since there is nothing before it, and therefore it can be accounted for only in terms of a personal explanation. Moreover, the personhood of the cause of the universe is implied by its timelessness and immateriality, since the only entities we know of which can possess such properties are either minds or abstract objects, and abstract objects do not stand in causal relations. Therefore the transcendent cause of the origin of the universe must be of the order of mind. This same conclusion is also implied by the origin of a temporal effect from a timeless cause. For if the cause of the universe were an impersonal set of necessary and sufficient

conditions, it could not exist without its effect. The only way for the cause to be timeless and changeless but for its effect to originate *de novo* a finite time ago is for the cause to be a personal agent who freely chooses to bring about an effect without antecedent determining conditions. Thus, we are brought, not merely to a transcendent cause of the universe, but to its personal creator.

## Naturalistic Objections

The naturalist, of course, will be reluctant to take on board such metaphysical baggage. But think of the alternative: that the universe came into being uncaused out of nothing. That seems metaphysically absurd. The naturalist philosopher of science Bernulf Kanitscheider remonstrates, 'If taken seriously, the initial singularity is in head-on collision with the most successful ontological commitment that was a guiding line of research since Epicurus and Lucretius,' namely, *out of nothing nothing comes*, which Kanitscheider calls 'a metaphysical hypothesis which has proved so fruitful in every corner of science that we are surely well-advised to try as hard as we can to eschew processes of absolute origin' (Kanitscheider 1990: 344). Mario Bunge thinks that an absolute origin of the universe 'would be unscientific, for science abides by the principles that nothing comes out of nothing or turns into nothingness . . . and that everything happens according to law rather than miracles' (Bunge 1985: 238-9). On the basis of the first principle Bunge, like Kanitscheider, rejects the view that the universe came into being uncaused out of nothing. On the basis of the second principle he thinks to reject theism. But while the principle that *out of nothing nothing comes* is a first principle of metaphysics as well as science, there is no incompatibility between being a theist metaphysically and a methodological naturalist scientifically; moreover, even methodological naturalism is far from unchallengeable. [xxxiv] It is difficult to see how any sensible person, particularly the naturalist, can think that the universe just sprang into existence uncaused out of nothing.

It has therefore been remarkable to observe in recent years the number of naturalists who, under the force of the evidence for an absolute beginning of the universe, have embraced the view that the universe is a surd contingent, something which popped into existence uncaused

out of nothing. Quentin Smith declares, 'The fact of the matter is that the most reasonable belief is that we came from nothing, by nothing and for nothing'. [i] Rather than posit a cause of the origin of the universe, Smith advises, 'We should instead acknowledge our foundation in nothingness and feel awe at the marvelous fact that we have a chance to participate briefly in this incredible sunburst that interrupts without reason the reign of non-being' (Smith 1993a: 135).

Sometimes attempts are made to render this remarkable hypothesis more plausible, but these are usually not very impressive. Consider, for example, Peter Atkins's account of the origin of the universe:

Now we go back in time beyond the moment of creation, to when there was no time, and to where there was no space . . . In the beginning there was nothing . . . .By chance there was a fluctuation, and a set of points, emerging from nothing, . . . defined a time . . . . From absolute nothing, absolutely without intervention, there came into being rudimentary existence . . . . Yet the line of time collapsed, and the incipient universe evaporated, for time alone is not rich enough for existence. Time and space emerged elsewhere, but they too crumbled back into their own dust, the coalescence of opposites, or simply nothing. Patterns emerged again, and again, and again. Each time the pattern formed a time, and through their patterning into time, the points induced their own existence . . . . Sometimes chance patterned points into a space as well as a time . . . . Then, by chance, there came about our fluctuation. Points came into existence by constituting time but, this time, in this pattern time was accompanied by three dimensions of space . . . with them comes stability, later elements, and still later elephants' (Atkins 1992: 129, 149-51).

This account is so obviously incoherent in postulating time before time and so confused in its reification of mathematical entities that we may rightly dismiss it as the pseudo-scientific drivel that it is. [ii]

Or again, when John Gribbin asserts that the origin of the universe from nothing presents no problem, since the positive energy associated with mass is precisely offset by the negative energy associated with gravitation, so that in the

case of the origin of the universe we got 'Not something for nothing, after all, but *nothing* for nothing' (Gribbin 1986: 374), he commits himself to the absurd position that nothing exists (not even he himself!). At the very best, the fact that the universe contains counter-balancing amounts of positive and negative energy could show that the universe need not have a material cause; but it does nothing to obviate the need for an efficient cause. As Isham puts it, there is still the 'need for ontic seeding' to produce the positive and negative energy, even if on balance it is naught (Isham 1994: 8). That is why the quantum vacuum was needed as a substratum in cosmogonic theories postulating such a process.

More often naturalistic thinkers have sought to commend their view either by attacking the causal principle *whatever begins to exist has a cause* or else by arguing for the implausibility or incoherence of the existence of a cause of the universe. Attacks on the causal principle are usually based on an appeal to quantum indeterminacy. For example, virtual particles are sometimes said to constitute a counter-example to the principle because they spring uncaused from the quantum mechanical vacuum. Wholly apart from the disputed question as to whether virtual particles really exist at all, [iii] the central point to be understood here is that the quantum vacuum on which they depend for their existence is not nothing. It is for that reason that the statements frequently made with respect to Vacuum Fluctuation Models that 'the universe quantum tunneled into being out of nothing,' or that 'nothingness is unstable' to fluctuations which grow into universes, or that 'the universe is a free lunch' because in this case 'we got something for nothing' cannot be taken seriously, for they treat nothing as though it were something, a sort of substance possessing properties and governed by the laws of quantum physics. In fact such statements turn out to be just rhetorical flourishes which no informed scientist takes literally. The quantum vacuum, which underlies all of space-time reality, is a fluctuating sea of energy. Because the vacuum is a physical entity existing in space and time, Vacuum Fluctuation Models did not envision a genuine origin of the universe out of nothing, as Kanitscheider emphasizes:

The violent microstructure of the vacuum has been used in attempts to explain the origin of the

universe as a long-lived vacuum fluctuation. But some authors have connected with this legitimate speculations [sic] far-reaching metaphysical claims, or at most they couched their mathematics in a highly misleading language, when they maintained 'the creation of the universe out of nothing' . . .

From the philosophical point of view it is essential to note that the foregoing is far from being a spontaneous generation of everything from naught, but the origin of that embryonic bubble is really a causal process leading from a primordial substratum with a rich physical structure to a materialized substratum of the vacuum. Admittedly this process is not deterministic, it includes that weak kind of causal dependence peculiar to every quantum mechanical process (Kanitscheider 1990: 346-7).

Thus, quantum physics does not serve to rebut the principle that whatever begins to exist has a cause.

It is not surprising that naturalists should attack the notion of a cause of the universe, since they reject supra-natural realities independently of their motivation to justify an uncaused origin of the universe from nothing. Sometimes these critiques may be easily dismissed. For example, metaphysician John Post obviously begs the question when he claims that there cannot be a cause of the origin of the universe, since 'by definition the universe contains everything there is or ever was or will be' (Post 1991: 85). Again it is an obvious *non-sequitur* when he infers that because 'the singularity cannot be caused by some earlier *natural* event or process,' therefore 'the universe has an uncaused beginning' and 'it seems contemporary physical cosmology cannot be cited in support of the idea of a *divine* cause or creator of the universe'(Post 1991: 87).

On the other hand, Smith realizes that the metaphysician must take seriously the 'more difficult question' of 'whether or not the singularity or the Big Bang probably is an effect of a supernatural cause, God' (Smith 1993a: 120). What problems, then, are there with a supernaturalist perspective? Adolf Grünbaum has argued vigorously against what he styles 'the New Creation Argument' for a supernatural cause of the origin of the universe. [v]

It seems to me that the supernaturalist has a number of options for dealing with this objection, one of which is to hold that the transcendent cause of the universe is causally, but not temporally, prior to the Big Bang event, such that His act of causing the universe to begin to exist is simultaneous, or co-incident, with its beginning to exist. Grünbaum provides no justification for his assumption that causal priority implies temporal priority. Discussions of causal directionality deal routinely with cases in which cause and effect are simultaneous. A supernaturalist could hold that the Creator sans the universe exists changelessly and, hence, timelessly and at the Big Bang singularity created the universe along with time and space. For the Creator sans the universe, there simply is no time because there are no events of any sort; time begins with the first event, at the moment of creation.

The time of the first event would be not only the first time at which the universe exists, but also, technically, the first time at which God exists, since sans the universe God exists timelessly. [vi] The moment of creation is, as it were, the moment at which God enters time. His act of creation is thus simultaneous with the origination of the universe.

In response to this suggestion, Grünbaum has opposed the following argument: [vii]

1. The proponent of simultaneous, asymmetric causation must furnish a generally accepted criterion for distinguishing one of two causally connected simultaneous events as the cause of the other, if simultaneous, asymmetric causation is possible.
2. There is no generally accepted account of causal directionality.
3. Therefore, there can be no simultaneous, asymmetric cause of the Big Bang.

The argument, if successful, would eliminate all purported instances of simultaneous, asymmetric causation, not just a cause of the Big Bang.

The argument, however, is, I think, unsound because (1) is so obviously false. For (i) Why must the proponent of simultaneous, asymmetric

causation furnish a *generally accepted* criterion of causal directionality in order for such causation to be possible? Is this not an extravagant demand? Grünbaum fails to appreciate that there is no generally accepted account of causal directionality *überhaupt*, including accounts which appeal to temporal priority as a condition of causal priority. Indeed, I should dare to say that there is no generally accepted account of causation at all today. But should we therefore infer that causation is impossible or non-existent? Compare the situation in contemporary epistemology. There is today no generally accepted account of justification or rational warrant with respect to beliefs we hold to be true; but should we therefore infer that knowledge is impossible? Deconstructionists and other post-modernists may think so, but I doubt that Grünbaum would be ready to follow in their train. There is no reason to think that the possibility of simultaneous causation depends upon our being able to come up with an uncontroversial criterion of causal directionality. (ii) Indeed, what reason is there to think that the possibility of simultaneous, asymmetric causation depends upon my being able to come up with any kind of criterion of causal directionality at all? My enunciation of a criterion for distinguishing a cause from its effect is an epistemic affair; the existence of simultaneous causation is a matter of ontology. A criterion helps us to *discern* simultaneous, asymmetric causes in the world; but to suggest that said criterion somehow *constitutes* such causal relations in reality is verificationism at its most implausible. Grünbaum has not suggested any incoherence or difficulty in simultaneous, asymmetric causation; if there are such causes in the world, they do not have to wait around for us to discover some criterion for distinguishing them. (iii) There is no reason to think that in order for specific cases of simultaneous, asymmetric causation to be possible or discernible, one must be able to furnish a general criterion broad enough to cover all such alleged cases. All one needs is a way of distinguishing cause from effect in the specific case. Now in the case of the hypothesis of theological creationism, we have a logically airtight means of distinguishing cause from effect, namely, it is *metaphysically impossible* for God to be caused by the world, since if God exists, His nature is such that He exists necessarily, whereas the world's existence is metaphysically contingent (as is evident from its

beginning to exist). That entails that there is *no possible world* in which God is caused by the Big Bang. Hence, it is easy for the theist to explain in what sense God is causally prior to the universe or the Big Bang: God and the universe are causally related, and if the universe were not to exist, God would nevertheless exist, whereas there is no possible world in which the universe exists without God. Thus, it seems to me that Grünbaum's objection to a supernatural cause of the origin of the universe is unsuccessful.

The naturalist will perhaps raise a metaphysical objection to the scenario I have sketched of the Creator's status sans the universe. For it requires that we conceive of a timeless, personal agent, and some philosophers have argued that such a notion is self-contradictory. [viii] For it is a necessary condition of personhood that an individual be capable of remembering, anticipating, reflecting, deliberating, deciding, and so forth. But these are inherently temporal activities. Therefore, there can be no atemporal persons.

The fallacy of this reasoning is that it conflates *common* properties of persons with *essential* properties of persons. The sorts of activities delineated above are certainly common properties of temporal persons. But that does not imply that such properties are essential to personhood. Arguably, what is necessary and sufficient for personhood is self-consciousness and free volition, and these are not inherently temporal. In his study of divine timelessness, John Yates writes,

The classical theist may immediately grant that concepts such as reflection, memory, and anticipation could not apply to a timeless being (nor to any omniscient being), but this is not to admit that the key concepts of consciousness and knowledge are inapplicable to such a deity . . . there does not seem to be any essential temporal element in words like . . . 'understand,' to 'be aware,' to 'know,' and so on . . . an atemporal deity could possess maximal understanding, awareness, and knowledge in a single, all-embracing vision of himself and the sum of reality (Yates 1990: 173).

Similarly, God could possess a free, changeless intention of the will to create a universe with a

temporal beginning. Thus, neither self-consciousness nor free volition entail temporality. But since these are plausibly sufficient for personhood, there is no incoherence in the notion of a timeless, personal Creator of the universe.

More recently Smith has argued that 'the thesis that universe has an originating divine cause is logically inconsistent with all extant definitions of causality and with a logical requirement upon these and all possible valid definitions or theories of causality (Smith 1996: 169-70). Smith shows that the typical analyses of the causal relation in terms of temporal priority, spatio-temporal contiguity, and nomological relatedness are inapplicable to the event of God's willing that the Big Bang occur and the event of the occurrence of the Big Bang. Therefore, these two events cannot, on the customary analyses, be regarded as cause and effect. Counterfactual analyses of causation, such as David Lewis's, according to which *c* causes *e* iff (i) *c* and *e* are both events which occur and (ii) if *c* had not occurred, *e* would not have occurred, fare no better in Smith's view. For if *c* is God's willing and *e* is the Big Bang, it is true that if *e* had not occurred, then *c* would not have occurred. But this implies that the Big Bang is the cause of God's willing, which is false. Lewis avoids the problem of spurious reverse causal dependence by stipulating that if *e* had not occurred, then *c* would have occurred but failed to cause *e*. But since God is omnipotent and His willing necessarily effective, such a stipulation cannot be made in the present case. Thus, under no extant analysis of causality can God be said to cause the Big Bang.

Smith's argument may be formulated as follows:

4. If the claim that God caused the Big Bang cannot be analyzed in terms of extant definitions of causality, then God cannot have caused the Big Bang.
5. The claim that God caused the Big Bang cannot be analyzed in terms of extant definitions of causality.
6. Therefore, God cannot have caused the Big Bang.

Is this argument sound and persuasive? I think not.

Consider premise (4). I see no reason to think that this premise is true. In general, arguments to the effect that some intuitively intelligible notion cannot be analyzed in terms of current philosophical theories ought to make us suspect the adequacy of those theories rather than reject the commonsense notion. The idea that God caused the universe is intuitively intelligible. A cause is, loosely speaking, something which produces something else and in terms of which the thing that is produced can be explained. That notion certainly applies to God's causing the universe. Indeed, God's causing certain effects is analogous to our acting as agents to bring about certain effects. We certainly conceive of ourselves as causes, and, intuitively, God should count as a cause as well. But Smith's argument, if successful, could be generalized to prove that God is not a cause of anything whatsoever. If God's acting as a cause cannot be analyzed in terms of current philosophical definitions of causation, then so much the worse for those definitions! That only shows that the definitions need to be revised. Indeed, the standard procedure in terms of which proposed definitions of causality are assessed is to postulate counter-examples of intuitively obvious cases of causation and then show how the definition fails to accommodate these examples. In the same way, if God's being a cause cannot be accommodated by some philosophical definition of causality, then that plausibly constitutes a counter-example to the definition which shows its inadequacy as a general metaphysical analysis of the causal relation, however adequate it might be for scientific purposes. [ix]

Moreover, there is no reason to believe that we have arrived at the final and correct analysis of causation. In fact, there is good reason to believe the opposite. The definitions discussed by Smith are exclusively concerned with natural, even physical, causes. They were not intended to cover such recondite cases as divine causation of the origin of the universe. It is hardly surprising, therefore, that these analyses should fail to capture this notion. Smith simply ignores analyses of causation which are not currently fashionable but which were crafted in the context of a theistic metaphysic and are consonant with God's being the cause of the origin of the universe, for example, the account of efficient causation and

creation given by Francisco Suarez in his monumental *Disputationes metaphysicae* (Suarez 2002). In his lengthy Introduction to his translation of questions 20-22 of Suarez's work, Freddoso argues that Suarez's account of causality not only enables one to construe God's creation of the universe as an instance of causation but also contrasts favorably with empiricist accounts of causality offered by contemporary philosophers such as Mackie, Lewis, van Fraassen, and Tooley.

Finally, Smith just assumes that an analysis of the causal relation can be given. But it could be held that such a relation is conceptually primitive, in which case we should not expect a successful reductive analysis to exist which will cover all cases. The plethora of competing extant analyses and the recognized deficiencies of all of them lend credibility to this viewpoint.

What about premise (5)? It seems to me that there are analyses of causation, however inadequate, which can accommodate God's causing the Big Bang. Consider Lewis's analysis of causation. According to Lewis, *c* causes *e* if and only if *c* and *e* are both events which occur and if *c* had not occurred *e* would not have occurred. Now God's willing the Big Bang clearly satisfies this definition: God's willing and the Big Bang are both events which occur, and if God's willing had not occurred, the Big Bang would not have occurred. But Smith rejoins, 'But if the Big Bang had not occurred, God's willing would not have occurred. So is the Big Bang the cause of God's willing?' Obviously not; but what this calls into question is the *adequacy* of Lewis's analysis, not whether divine causation satisfies it. Lewis remedies the problem by stipulating that if *e* had not occurred, *c* would still have occurred but failed to cause *e*, a remedy which will not work for divine causation. Actually Lewis's remedy will not work for many natural causes either, since in some cases the counterfactual, 'If *e* had not occurred, *c* would not have occurred' is true. So what Lewis's definition gives is not an analysis of '*c* causes *e*' but rather an analysis of '*c* and *e* are causally related,' and it fails to specify the *direction* of causation. But the theist faces no problem there: for, as we have said, it is metaphysically impossible for God's willing to have an external cause. There is no possible world in which the Big Bang causes God's volition. Therefore, given Lewis's analysis of '*c* and *e* are

causally related' and the impossibility of the Big Bang's causing God's willing, it follows that God's willing causes the Big Bang. Thus, divine causation satisfies Lewis's definition of causality.

Again, there are analyses of agent causation which are even more relevant in the case of divine causation than the analyses surveyed by Smith. Smith considers exclusively event causation, but it may be disputed whether this is the correct conception to apply to God's case. Smith contends that considerations of agent causation are not germane to the discussion because we are not concerned with the relation between God (the agent) and His act of willing (the effect), but with the relation between His act of willing (an event) and the Big Bang (an event). But not all proponents of agent causation construe agent causation as a relation between an agent and his volitions. Some proponents of agent causation hold that an agent does not cause his volitions, but that by freely willing he brings about some intended event (Lowe 2002: 205-10). In the case at hand God brings about the Big Bang by an exercise of His active power. The expression 'God's willing that the Big Bang occur' properly describes an action, not an event. The event in this case is the Big Bang, and the cause of that event is God, who, by willing, brought about the Big Bang. Thus, it is simply wrong-headed to think of the Big Bang as caused by the event of God's willing rather than by God Himself. [x]

Thus, neither (4) nor (5) commends itself to us as more plausibly true than its contradictory. Smith recognizes these deficiencies of his argument, but he falls back to what he considers an impregnable position: 'c is a cause of e' entails 'c is not a logically sufficient condition of e' (Smith 1996: 176). This entailment precludes God's being the cause of the Big Bang because God's willing that the Big Bang occur is a logically sufficient condition of the Big Bang. This is because God is omnipotent, and thus necessarily His will is successful. There is no possible world in which God wills the Big Bang and yet the Big Bang fails to occur. Therefore, God cannot be the cause of the Big Bang.

This argument seems quite fanciful. If successful, it can be generalized to show that God cannot cause anything. Thus, precisely *because* He is

omnipotent, God is utterly impotent--a curious inference! If being omnipotent entails inability to cause anything, then we are using "cause" in a highly technical sense which is not incompatible with God's bringing a'causes' the Big Bang, it is still up to Him whether it occurs or not, and it occurs only in virtue of His willing that it occur. If it seems that bringing about the Big Bang does involve a causal relation, then we shall simply reject Smith's entailment principle. Only someone who is already a naturalist would be tempted to think that that principle is true. Thus, Smith's argument is either question-begging or not incompatible with God's bringing about the Big Bang.

Smith considers such a response and insists that it is the theist who begs the question, since in every other case of causation causes are not logically sufficient conditions of their effects. There is, he says, no justification for exempting God's alleged acts of causation from this principle. We need to have some independent reason for thinking that the relation between God and the Big Bang is a causal relation. Three things may be said about this response: (i) Since only God is omnipotent, it is hardly surprising that His case should be the sole exception to the principle that causes are not logically sufficient for their effects. God is so exceptional a being that He will in general not fit into our customary schemata. For example, it is a general principle that 'S believes p' is not a logically sufficient condition of 'p.' But since God is essentially omniscient, in God's case His believing p is a logically sufficient condition of p. Should we therefore conclude that God has no beliefs? In the same way, because God is omnipotent, are we to think that His will has no effects? (ii) There are other plausible counter-examples to Smith's principle. For example, change is plausibly a cause of the existence of time, at least on a relational view of time. The occurrence of events actually brings time into existence. If there were an absolutely quiescent state then time would not exist. But if a change occurs, time is immediately produced. Such a relation is plausibly causal; it is certainly not like the purely logical relation between, say, a two-dimensional figure's having three sides and its having three angles. Time is something altogether distinct from change, since time can go on, even most relationalists agree, even though change should cease (Shoemaker 1969). Thus, change, should it occur, would seem to cause time to

exist. Yet change necessarily causes time: there is no possible world in which change is going on without time. Change is thus logically sufficient for the existence of time, but is also plausibly a cause of time's existence. (iii) The reason that the relation between God and the Big Bang--or any other event He brings about--is causal is the close resemblance between God and ourselves as agents. Doubtless our deepest intuitions about causality are rooted in our own ability to bring about effects by an intentional exertion of our power. But God is a personal agent like ourselves. The difference between Him and us is that His power is so great that He is infallible in bringing about His undertakings. Is His status as a cause now to be doubted because He is infallible? Hardly! In short I do not think that Smith's objection poses a serious obstacle to thinking that the Big Bang has a supernatural or divine cause.

All of the above objections have been considered as attempted justification of the apparently incredible position that the universe sprang into being uncaused out of nothing. But I, for one, find the premises of those objections far less perspicuous than the proposition that *whatever begins to exist has a cause*. It is far more plausible to deny one of those premises than to affirm what Hume called the 'absurd Proposition' that something might arise without a cause, [xi] that the universe, in this case, should pop into existence uncaused out of nothing.

## CONCLUSION

We can summarize our argument as follows:

1. Whatever exists has a reason for its existence, either in the necessity of its own nature or in an external ground.
2. Whatever begins to exist is not necessary in its existence.
3. If the universe has an external ground of its existence, then there exists a Personal Creator of the universe, who, sans the universe, is timeless, spaceless, beginningless, changeless, uncaused, and enormously powerful.
4. The universe began to exist.

From (2) and (4) it follows that

5. Therefore, the universe is not necessary in its existence.

From (1) and (5) it follows further that

6. Therefore, the universe has an external ground of its existence.

From (3) and (6) it we can conclude that

7. Therefore, there exists a Personal Creator of the universe, who, sans the universe, is timeless, spaceless, beginningless, changeless, uncaused, and enormously powerful.

And this, as Thomas Aquinas laconically remarked, is what everyone means by 'God.' [xii]

## NOTES

Smith (1993a): 135. Elsewhere he has written,

'[This world] exists non necessarily, improbably, and causelessly. It exists *for absolutely no reason at all* . . . The impact of this captivated realization upon me is overwhelming. I am completely stunned. I take a few dazed steps in the dark meadow, and fall among the flowers. I lie stupefied, whirling without comprehension in this world through numberless worlds other than this' (Smith 1986: 300-1).

In *Theism, Atheism, and Big Bang Cosmology*, Smith claimed that the universe came into being uncaused out of nothing at the Planck time; but he has since recanted that position under the realization that the whole field of quantum cosmology is then studying a complete fiction!

[ii] John Leslie asks incredulously, 'How could such nonsense have been churned out by the author of *Physical Chemistry*, a superb textbook?' (Leslie 1993: 3). For a good critique of Atkins, see Ward (1996), chap. 1.

[iii] See Weingard, (1982): 235-42.

Grünbaum (1989). For a response, see Craig (1992).

Grünbaum (1991). For a response, see Craig

(1994a).

Brian Leftow puts this nicely when he writes,

'If God existed in time once time existed and time had a first moment, then God would have a first moment of existence: there would be a moment before which He did not exist, because there was no 'before' that moment . . . Yet even if He . . . had a first moment of existence, one could still call God's existence unlimited were it understood that He would have existed even if time did not. For as long as this is true, we cannot infer from God's having had a first moment of existence that God *came into* existence or would not have existed save if time did" (Leftow 1991: 269; cf. 201).

Senor has dubbed such a model of divine eternity 'accidental temporalism' (Senor 1993: 88). See further Craig (1996c).

Grünbaum (1994). For a response, see Craig (1994b).

See discussion and references in Craig (1998b).

In Smith (1993b), Smith actually arrives at this conclusion himself. He states,

'extant definitions of causality are incorrect since they do not cohere in the proper way with the concept of a cause of the universe . . .

This entails that either there is some other (as yet undiscovered) definition of a cause that is correct or that a cause is indefinable. In the latter case, the concept of a cause would be primitive and the causal relation a simple relation known only by ostension (as is arguably the case with such relations as *being in contact with* or *being earlier than*). I know of no means of discovering or formulating a correct definition of a cause and know of no reason to think that there is such a definition. Accordingly, I think it is reasonable to conclude that the causal relation is indefinable.

One way to avoid this conclusion would be to reject the assumption that the various examples of causes of the big bang . . . are genuine examples of causes . . . I would say that claims that God's creation of the big bang singularity and other examples given . . . are not cases of possible causation are counterintuitive and are *ad*

*hoc* attempts to retain a counterexampled theory. It is more plausible to think that a cause cannot be defined than to think that a mind's creation of a big bang singularity could not be a causal act" (Smith 1993b: 1, 24).

Smith came to think God's relation to the Big Bang is not causal because no cause is logically sufficient for its effect. But Smith does not justify why the actions of an omnipotent being would not be exceptions to this rule.

[x]See Moreland (1998). I am indebted to my colleague for several interesting discussions pertinent to agency and creation.

David Hume to John Stewart, February, 1754, in Greig (1932), 1: 187.

1a.2.3.

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