Indications of Creation in Contemporary Big Bang Cosmology[1]

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Introduction

Contemporary astrophysics has opened the way for a remarkably deep insight into the creation and nature of the universe. The General Theory of Relativity, Hubble's redshifts, Penzias' and Wilson's discovery of a universal background radiation, the discovery of black holes, Quantum Theory, and a host of other discoveries have led to a grand scheme of universal origins called "Big Bang cosmology." In the view of many physicists and philosophers, this remarkable cosmological theory points to a creation event as well as an ordered unfolding of the universe which is virtually inexplicable without a determinative ordering principle. In 1983, Paul Davies connected the evidence of physics to the finite age of the universe:

> If we accept that space and time really did erupt out of nothing in the big bang, then clearly there was a creation and the universe has a finite age. The paradox of the second law of thermodynamics is therefore immediately solved. The universe has not reached thermodynamic equilibrium yet because it has only been disordering itself for eighteen billion years or so, and that is nowhere near long enough to complete the process. Moreover, we can now understand why all of the galaxies have not fallen together. The explosive violence has flung them apart, and even though their rate of separation is slowing, there has not yet been enough time for them to fall back on themselves… If the big bang theory rested on the work of Hubble and Einstein alone, it would not command the widespread support that it does. Fortunately, there is some persuasive confirmatory evidence. … The fact that modern cosmology has provided hard physical evidence for the creation is a matter of great satisfaction to religious thinkers.[2]

Today, most physicists would not make this kind of direct claim because of several recent additions to the classical Big Bang model. The four most influential changes are:

1) the probability of an inflationary era,

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[2] Davies 1983, pp. 20-24.

2) the vacuum energy (sometimes termed “dark energy” because of a lack of luminosity) intrinsic to that era,
3) difficulties with the singularity hypothesis,
4) the possibility of a pre-Big-Bang unified era.

These developments have added considerable complexity to what is now known as the “contemporary Big Bang model” which makes the insight into a creation event less direct, but makes the insight into universal design more probative and beautiful.

Though the contemporary Big Bang model still indicates that the post-Big-Bang *observable* universe is finite in space and time, it does not account for what is termed “the universe as a whole” which considers two additional possibilities:

1) a pre-Big-Bang unified era
2) space beyond the observable universe.

If the above two conjectures are not correct (and therefore, if the universe originated with the Big Bang and is limited in extent to the observable universe), physics would provide a strongly probative argument for a creation event through the finitude of universal past time. However, the possibility of a pre-Big-Bang era and space beyond the observable universe requires an investigation into domains about which physics can only speculate. Nevertheless, a philosophy of space and time can be applied to the notion of physical simplicity (i.e., a unified era), and to the conditions of spatiality to show that the finitude of the post-Big-Bang universe probably extends to a pre-Big-Bang universe (if, indeed, such a pre-Big-Bang universe existed). Thus, the combination of philosophical evidence (an ontology of space and time) and physical evidence (a notion of physical simplicity in a unified era) can provide considerable evidence for the finitude of universal past time, and therefore, for a creative event at the universe’s first moment.

If a pre-Big-Bang universe existed, then it would both enhance the probative force of arguments for universal design, and reveal the magnanimity and beauty of that universal design. This insight was quite poignant in the *classical* Big Bang model, as evidenced by two of the greatest contributors to that model – Roger Penrose[3] and Arno Penzias:

> Astronomy leads us to a unique event, a universe which was created out of nothing, and delicately balanced to provide exactly the conditions required to support life. In the absence of an absurdly improbable accident, the observations of modern science seem to suggest an underlying, one might say, supernatural plan.[4]

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[3] “If the initial state were chosen at random, it seems exceedingly probable that the big bang would have coughed out black holes rather than dispersed gases. The present arrangement of matter and energy, with matter spread thinly at relatively low density, in the form of stars and gas clouds would, apparently, only result from a very special choice of initial conditions. Roger Penrose has computed the odds against the observed universe appearing by accident, given that a black-hole cosmos is so much more likely on *a priori* grounds. He estimates a figure of $10^{10^{30}}$ to one (Davies 1983, p. 178. See also, Penrose 1979).”

[4] Brock 1992 cited in Bradley 1998, p. 40.

If a pre-Big-Bang universe existed, it would have had to have done so through a unified field, the physics of which is radically different from the post-Big-Bang (General Theory of Relativity) field. This means that the initial conditions of a universe of gases and galaxies was not only intrinsic to the Big Bang, but also to an era whose physics was radically different from the one in which the gases and galaxies emerged. The unfolding of one kind of universe into another would seem to reveal even more poignantly and beautifully Penzias' "underlying supernatural plan."

This investigation will be divided into the following sections:

I. The finitude of the post-Big-Bang universe according to the *classical* Big Bang model
II. The probable finitude of the "universe as a whole" according to the *contemporary* Big Bang model
III. Conclusions concerning creation and design.

I.
The Finitude of the Post-Big-Bang Universe

The classical Big Bang model gives considerable evidence for the finitude of the post-Big-Bang universe through four methods:

1) thermodynamics,
2) the radiation / cyclic expansion paradoxes,
3) the calculation of an open universe (without the identification of vacuum energy and an inflationary era) and
4) the probability of a universal singularity.

As will be shown below, the first two methods are as valid today as they were in classical Big Bang cosmology. However, the second two methods were mitigated by the probability of an inflationary era (predicted by Andre Linde and others) which pointed to the presence of large quantities of vacuum energy in the universe.

Vacuum energy is evidenced in the "borrowing" of energy for virtual particle pair creation within a quantum system. It is different from mass energy in that it opposes gravity and actually increases in magnitude with distance. When Linde and others discovered the probability of an inflationary era, they also pointed to the probable existence of vacuum energy in the universe as a whole (i.e., in addition to the vacuum energy in quantum systems). This had the effect of undermining the calculation of an open (solely expanding) universe on the basis of mass energy's effect on total universal gravity. However, the presence of such vacuum energy requires the universe to expand (and not to contract) from the moment of the Big Bang, onward. Thus, the undermining of one method of showing the finite age of the post-Big-Bang universe led to another more conclusive one.

The presence of vacuum energy also mitigated the fourth method for determining a finite age of the universe (the universal singularity hypothesis of Stephen Hawking and Roger Penrose). Prior to 1985, the Hawking-Penrose Singularity was considered to be one of the most probative pieces of physical evidence of a limit to past time in the universe. In 1980, Hawking wrote, “a curvature singularity that will intersect every world line…[makes] general relativity predict a beginning of time.”[5]

Quentin Smith, summarizing Hawking and Penrose, lists the five conditions necessitating a singularity according to standard GTR:

> (1) space-time satisfies the equations of GTR, (2) time travel into one’s own past is impossible and the principle of causality is not violated (there are no closed time-like curves), (3) the mass density and pressure of matter never become negative, (4) the universe is closed and/or there is enough matter present to create a trapped surface, and (5) the space-time manifold is not too highly [a]symmetric.[6]

Prior to the discovery of evidence for an inflationary era (and its vacuum energy), all five of these conditions were thought to be met in the universe. Quentin Smith summarized the consequences of this by noting:

> …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 that is employed in the singularity theorems entails that it is *impossible* to extend the space-time manifold beyond the singularity. The definition in question is based on the concept of inextendible curves [which must avoid implying infinite curvature and other similar mathematical paradoxes]…. This effectively rules out the idea that the singularity is an effect of some prior natural process.[7]

However, the increasing likelihood of an inflationary era (with the accompanying vacuum energy required to produce it) changed this reasoning, because it violates the third of the above conditions (the mass density and pressure of matter never become negative). If there was an inflationary period at the early phase of the universe, then there would exist a very strong pressure associated with the universe’s vacuum energy which is equal to *minus* the density. Recall that vacuum energy is different from mass energy in that it opposes gravity and increases in magnitude with distance. The presence of this energy would then exert a very strong negative pressure of matter, violating Hawking’s third condition. Though this result mitigates the *prediction* of a singularity in the GTR model, it does not rule out the occurrence of a singularity at the beginning of universal space-time asymmetry. In any event, a singularity is only one of a myriad of different ways in which an intrinsic limit to universal time might be manifest.

Inasmuch as universal inflation is unlikely to have occurred infinitely throughout the past,[8] then the universe would seem to either:

1) have a beginning at the inception of inflation (the Big Bang), or

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[5] Hawking 1980, p.149.

[6] Smith 1993(a), p. 114. Smith notes “the space-time manifold is not too highly *symmetric*.” This must be a typo because one cannot imagine a space-time manifold being more symmetric than that discovered by Friedmann-Robertson-Walker.

[7] Smith 1993(a), p. 120.

[8] See Alan Guth’s apprehensions in Section II.A, below, and in Guth 2001, p.12.

2) have a pre-Big-Bang (pre-inflationary) unified era ("Planck era") which would have had to have evolved into a first inflationary period.

The first option implies a beginning of universal time 13.7 billion years ago. The second option suggests a beginning of time at "13.7 billion years plus the time intrinsic to the Planck era."[9] As will be discussed in Section II, *physical* evidence can show the likelihood of the finitude of such a pre-Big-Bang era. *Philosophical* evidence can also show this through the Hilbertian paradox.[10]

In view of these changes to the Big Bang model, our consideration of the finitude of the post-Big-Bang universe will be divided into two parts:

A) the classical Big Bang model (without consideration of vacuum energy and an inflationary era), and
B) the contemporary Big Bang model (which postulates vacuum energy and an inflationary era).

I.A.
The Classical Big Bang Model

Classical Big Bang cosmology is grounded in the General Theory of Relativity (hereafter "GTR") which shows the interaction of gravity with the other three fundamental forces (electromagnetic, strong nuclear force, and weak force) through a dynamic space-time field. Though many current discoveries and theories have raised doubts about the sufficiency of GTR to describe a *pre*-Big-Bang, non-observable universe (e.g., the temperature of the Planck era, the quantum vacuum fluctuation hypothesis, the quantum gravity hypothesis, unknown effects of electromagnetic forces at the earliest stage of the universe, superstring theory, Linde's chaotic inflation theory, and the Hawking imaginary time conjecture), it is still considered valid for describing the *post*-Big-Bang, observable universe.

I.A.1.
The General Theory of Relativity

The Newtonian view of a universe of infinite space and time held sway for nearly 260 years. This assumption was dramatically changed when Einstein published his famous work on the General Theory of Relativity.[11] One of the peculiar predictions of GTR (first made by Friedmann) was the finitude of the observable universe. This prediction was later confirmed by the discoveries of Hubble,[12] Penzias and Wilson,[13] and many others.

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[9] Since this era implies the quantization of gravity, the notion of time intrinsic to it would be quite unusual. I try to show in Section II.B that ontological proto-time must apply even to this unusual period, which would indicate an asymmetry of events.

[10] See Spitzer 2003, pp. 35-106.

[11] Einstein 1998 and 1945. For a good contemporary interpretation by the author himself, see Einstein 1961.

[12] Hubble 1929, pp. 168-73.

[13] Penzias and Wilson 1965, pp. 419-21.

The General Theory of Relativity holds that space is neither nothingness nor an empty vacuum. It is a dynamic interrelational "field" through which mass-energy interacts. This dynamic field of interaction can vary in its metrical and geometrical configuration. When it does, it can become curved, and so curve the trajectory of mass-energy interacting through it. This would make the shortest distance between two points a curve! Perhaps stranger still, the metric of this field can vary so that the three-dimensional scale of an equal quantity of mass-energy could be different from place to place. The density of mass-energy manifest in deep space might be quite extensive compared to the density of mass-energy at the base of a black hole (where the relative scale of energy manifestation is considerably restricted). In essence, then, the General Theory of Relativity holds that where there is density of mass-energy, there is likely to be a shortening of the radius of curvature of space which implies a compression of the scale of space.[14]

Gravity no longer needs to be viewed as a Newtonian force. All gravitational effects can be explained in terms of the curvature of space. If, for example, a large amount of mass-energy is concentrated in a particular region, the radius of curvature of space will shorten, compressing the scale of space. Now, if some moving body (a second manifestation of mass-energy) should approach the first body, it will be drawn toward the compressed region (i.e., towards the shortest distance between two points). It will even orbit around the curvature of the compressed region (because the shortest distance between two points is a curved line in curved space – a geodesic). This explains "attraction at a distance" without making recourse to Newton's "*force* of attraction."[15]

Another oddity of the General Theory of Relativity is that mass-energy takes on the curvature (compressed scale) of the space through which it interacts. Thus, if a manifestation of mass-energy inheres in a region of space with a compressed scale, it too will take on that compressed scale. This peculiar quality opens the way to a bizarre phenomenon predicted by the General Theory, namely, black holes.

As a star collapses, it also compresses the scale of space (shortens the radius of curvature) in that region. The mass-energy of the star takes on the compressed scale of space in that region, which, in turn, compresses the scale of space even more, which, in turn, makes the star conform to the more compressed scale of space, etc., until the entire mass-energy of the star is situated in a single coordinate approximately 10^{-33} cm (the Planck minimum).

If a second manifestation of energy (say, a planet or a star) were in the region of the black hole, it would follow the spatial curvature of the black hole (towards the shortest distance between two points) until it could go no further (the base of the black hole). As it was moving toward the base, the front end of the star would take on a more compressed spatial scale than the back end of the star, making the star into a kind of spaghetti trailing around the curvature of the black hole. In ordinary circumstances, the star would not be able to reverse its direction and go in the direction of the greater distance between two points. Its fate, as it were, is sealed.

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[14] For an excellent explanation of this, see Steinmetz 1967, pp. 41-45. See also Einstein 1961, pp. 135-57.

[15] See Steinmetz 1961, pp. 54-59. It is interesting to note that Einstein was able to make a more accurate prediction of the orbit of Mercury around the Sun through the "curved space" model of gravity than Newton was able to make through his "force" model. The subtle differences had eluded observational astronomers until Einstein's Theory pointed to them. He was soon vindicated, and so was his peculiar, counterintuitive Theory. (See Einstein 1961, Appendix 3, pp. 123-32.)

The General Theory of Relativity can be and has been applied to the universe as a whole. It has been used to show the finitude of space in the observable universe, the finitude of time in the post-Big-Bang universe, the succession of events which are likely to occur in a universal collapse, and even the dynamics of universal expansion in inflationary and non-inflationary scenarios. Unfortunately, this grand theory does not extend to the pre-Big-Bang, non-observable universe.

I.A.2.

Cosmological Implications of Hubble's Redshifts

In 1929, the famous American astronomer Edwin Hubble made the remarkable discovery that the greater the distance a light source (such as a galaxy) is from the Earth, the more its spectral lines are displaced (shifted) toward the red (low frequency) end of the spectrum.[16] A brief explanation of this will reveal how Hubble was able to calculate the size, density, and age of the observable universe. Three aspects of elementary physics are needed to understand Hubble's discovery:

1) A redshift (the shifting of spectral lines toward the infrared end of the spectrum) indicates that an object is moving away from the observer,
2) an increase in the redshift indicates that an object is moving away from the observer more quickly, and
3) given the finite velocity of light (300,000 km/sec), the greater the distance a light source is from the observer, the older the origin of the light. Hence, light from a greater distance was emitted a longer time ago.

Hubble first discovered that galactic motion relative to our galaxy is dominated by redshifts. This means that the universe, as a whole, is expanding. Now, if the universe as a whole is expanding, then all galaxies are moving away from all other galaxies, implying that the universe has no center.

We are now prepared to interpret a second feature of Hubble's finding: the redshift increases in proportion to the distance from the Earth (i.e., the greater the distance from the Earth, the greater the redshift). Let us break this proposition down into two parts and translate them. Recall that "greater redshift" means "moving away from an observer faster," and "greater distance" means "a longer time ago."

Greater red shift	**Greater distance**
Things are moving away faster	A longer time ago

If things are moving away from me faster longer ago, they must be moving away from me slower today. In short, the observable universe was not only expanding, it was slowing down in its

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[16] Hubble 1929, pp. 168-73.

expansion.[17] This allowed Hubble and his followers to make a series of remarkable deductions which ran contrary to the hypothesis of an infinite universe. The following conclusions update those of Hubble and his followers to account for elements of the contemporary Big Bang model (particularly the inflationary era and a pre-Big-Bang unified era).

1) Gravity (what Newton described as the force of *attraction* between bodies, and what General Theory of Relativity calls the curved or compressed scale of space) is the cause of the slowing down of the universe's expansion in the past. By knowing the rate of deceleration, we can determine the strength of universal gravitation.

2) The density of mass-energy is what causes gravity to increase. The greater the density of mass-energy, the greater the gravity. If mass-energy were infinitely dense, so also would be gravity. If there is infinite attraction in the universe, the universe could never have expanded. Indeed, if it were already expanded, it would inexorably implode until it became similar to a black hole.

3) If the universe has experienced inflationary periods, it has probably only been in a state of expansion (see below, Section II). If one assumes that the unified era and the inflationary period immediately succeeding it were relatively short in duration, and the current inflationary period has been occurring only since the time of a redshift of .5, then the age of the universe can be calculated by using Hubble's constant which was applicable during the lengthy non-accelerating period (between the first and current inflationary periods). From these data, it seems that the observable universe is approximately 13.7 billion years old.[18]

4) In view of the above, the total mass of the observable universe must be finite (currently estimated at 10^{53} kg). Using this as a base, we can also calculate the approximate number of particles which *do not* have rest mass (e.g., photons) and derive reasonable estimates for the amount of energy in the observable universe. Though these numbers are quite large, they are nevertheless quite finite.

5) There is evidence to suggest that the early inflationary period of the universe was preceded by a superunified period (see below, Section II.C). In this super-unified period, what was to become the observable universe had a very small radius (approximately 10^{-33} cm) and a temperature above 10^{32}K, which would make the General Theory of Relativity inapplicable.

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[17] As will be indicated later, the universe likely experienced an inflationary phase at its earliest stages, then the above-mentioned decelerating phase, and perhaps today is re-experiencing an accelerating phase. The dynamics of the first accelerating (inflationary) phase will be explained in Section II.A. Many physicists believe that the universe could be experiencing acceleration (inflation) currently. The cause of this acceleration would be the very strong pressure associated with vacuum energy (sometimes referred to as "the cosmological constant"), which may well have become manifest after a redshift of approximately .5. Though vacuum energy gives rise to gravity, it has a very strong pressure which is equal to "minus density" associated with it. This means that its pressure will be stronger than the gravitational attraction induced by it, and will cause an overall acceleration of universal expansion (after a redshift of approximately .5). In view of this, Hubble's predictions about the deceleration of the universe attributable to gravity are valid prior to a redshift of approximately .5. The data given below are based on this limited use of Hubble's theory. Their validity is not affected by the universe being inflationary in the "post- .5 redshift" era.

[18] This calculation may viewed in Sandage and Tammann, vi: 197 (1975), pp. 265-80.

This period (which I have termed the "unified era," also called the "Planck era") has been variously described through quantum cosmology and superstring theory (see below, Section II.C). Parts of these theories may have validity in the description of this extreme phase of the universe.

6) After the unified era, the universe seems to have moved through several phases to arrive at nucleosynthesis (the generation of atomic nuclei):

(a) the inflationary era,
(b) the quark era (corresponding to elementary particle physics),
(c) the hadron era (100,000th of a second),
(d) the lepton era (one ten-thousandth of a second to ten seconds),
(e) the primordial nucleosynthesis era (1 to 3 minutes)
(f) the plasma era (3 minutes to 500,000 years – plasma physics), and
(g) the era of complex atomic nuclei and galaxies (sometimes referred to as the era of stellar nucleosynthesis).

Each of these eras represents its own branch of physics moving from the very elementary generation of particles (such as quarks and supposed gravitons) to protoparticles which have passed away, leaving "massless" remnants (such as photons) to short-lived interdeterminately existing particles (such as pi-mesons) to the particles which still exist in abundance today and constitute both simple and complex atomic nuclei (protons, electrons, and neutrons).

Hubble's theories were quite remarkably confirmed through the discovery of an independent form of evidence: a universal isotropic microwave background radiation.

I.A.3.
A Universal Isotropic Radiation

In 1965, two scientists from Bell laboratories, Arno Penzias and Robert Wilson, discovered a 2.76°K isotropic radiation almost perfectly uniformly distributed throughout the universe. The red-shifting of this very low level radiation indicated that it originated approximately 13.7 billion years ago. The universality of the radiation indicated that it originated at a very early stage of the universe. The uniform distribution of the radiation indicated that the universe expanded (in large scale) isotropically. If it had not, then the radiation would be distributed anisotropically.

A universal distribution of radiation is quite anomalous, for it cannot arise under ordinary circumstances. If an explosion happens in a particular region of space, the radiation (shock wave) from the explosion rushes out from the epicenter but is not present at all places from the epicenter. Furthermore, it is certainly not of the same intensity at each place from the epicenter, because it grows weaker as it moves away. What peculiar conditions, then, would give rise to a shock wave which is everywhere and uniform?

First, the radiation would have had to have been omnipresent at some primary stage of the universe. If it were not, the places where the radiation was not would simply become greater and greater as the universe expanded. Thus, if we are not going to postulate the *deus ex machina*[19] of a radiation of 2.76°K spontaneously appearing with an accompanying redshift (indicating a 13.7 billion year old age), it would be reasonable to admit that the radiation was omnipresent at some primary stage of the expansion.

Omnipresence does not necessarily entail uniform distribution (the same temperature at all places). So, how can the universe's uniform distribution of the red-shifted radiation be explained? If we look at the stages of nucleosynthesis, the most likely explanation seems to be that the universe emerged out of a primary moment with an ordered expansion.[20] There are many reasons for suspecting this besides the uniform distribution of the universal radiation.[21] For the moment, suffice it to say that the datum of the uniform radiation coincides almost perfectly with a variety of other independent data (including the General Theory of Relativity and Hubble's redshifts). This suggests that the universe moved out of its first moment in such a well-ordered way that it preserved the uniformity of the background radiation through all subsequent eras.

Conclusion to Section I.A.

The view of the observable universe as a finite, ordered, large-scale homogeneous, isotropically expanding whole is a far cry from Newton's infinite space with its aggregating mass points in a Euclidean vacuum.[22] As will be explained below, when this standard Big Bang view is modified to account for past and present inflationary eras, it reveals a finite age of the post-Big Bang universe and the possibility of a pre-Big-Bang (unified) era. Though physical evidence can show the finite age of the post-Big-Bang universe, it can only show a *likelihood* of a finite age of the pre-Big-Bang universe (see Section II.D). Given this probabilistic caveat, it seems likely that the universe began in a super-small, super-unified state, and emerged through a highly ordered process into a large-scale, well-ordered complexity.

By the end of this paper, I will show the likelihood of a finite age of the universe on the basis of physical evidence. This will be adduced in the following three steps throughout Sections I and II:

a) If the universe is indeed an inflationary one, then the universe has been solely expanding and did not undergo a series of expansions and collapses (see Section II.A).

b) Even if the universe did not have an inflationary period, it is still very likely to be open, for the mass density is not large enough (as determined by three distinct tests) to bring it to a halt and subsequent collapse (see Section I.B).

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[19] The term "*deus ex machina*," meaning "god out of the machine" comes from Greek and Roman drama where deities come out of theater machinery to magically resolve seemingly irresolvable conundrums in the plot.

[20] Linde, in his chaotic inflationary hypothesis, maintains that only our particular region has ordered expansion. Other unknown regions of the universe could have different rates of expansion which might be unknown to us. See Linde, 1998, pp. 98-104.

[21] Penrose 1979. See also, Davies 1983, pp. 178-79.

[22] Chaotic inflation may reduce this expanding whole to an isotropically expanding *region*. See Linde, 1998, pp. 98-104.

c) The physical modeling of the unified era (e.g., quantum cosmology and superstring theory) suggests that the universe (even in a pre-Big-Bang era) would have had to have been in a continuous state of dispersion (an increase in the distinction and separation of its forces and parts – see below, Section II.D). The universe would seem to have undergone a *finite* amount of continuous complexification (even in a pre-Big-Bang era), and therefore, would seem to have existed for only a finite amount of time. There are Hilbertian reasons for proscribing infinite time of this era,[23] but *physical* evidence (the transition from a unified era to a GTR era) would seem to suggest that a finite amount of continuous complexification would take a finite amount of time.

If the unified era is the universe's first era, and if that era was finite in duration (as the physical evidence seems to suggest), the beginning of the unified era would seem to represent a moment of universal creation. If time in this era (which is quite distinct from "time" in the GTR era) is asymmetrical (which will be shown below – Section II.B), and this asymmetrical time is finite, then the unified era would have to have an intrinsic temporal limit. There cannot be any "prior" to this limit, for there would be no time and no condition in which this "prior" would be manifest. If something is not to come from nothing, this condition would imply a causative force transcending space-time asymmetry.

I.B.
Three Physical Reasons for the Finitude of Space and Time in the Post-Big-Bang, Observable Universe

Physics has provided three kinds of evidence for the finite age of the post-Big-Bang universe:

1) entropy,
2) the unlikelihood of indefinite oscillation, and
3) a solely expanding universe predicted by both non-inflationary and inflationary scenarios.

I.B.1.
Entropy

The second law of thermodynamics postulates that every instance of work (a use of free energy in a system) gives rise to an overall increase in entropy within a total system (a state of energy which can no longer be used for work).[24] If the universe as a whole were considered a system, then its expansion and all the work within it would be continually increasing its entropy. Since work would occur within a universal collapse and even a universal black hole,[25] entropy is

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[23] See Spitzer 2003, pp. 35-106.

[24] Note that work could lead to a decrease in entropy within a certain *part* of a system, e.g., inside a refrigerator, but there would be increases in entropy in *other parts* of the system, giving rise to an overall increase in entropy in the total system.

[25] "Although the entropy of a general gravitating system is not known, work by Jacob Bekenstein and Stephen Hawking, in which the quantum theory is applied to black holes, has yielded a formula for the entropy of these objects. As expected, it is enormously greater than the entropy of, for instance, a star of the same mass." (Davies 1983, p. 178).

inescapable in virtually every universal condition. Therefore, if the universe had existed for an infinite amount of time, but only had a finite amount of work energy, it would have reached a state of maximum entropy (thermodynamic equilibrium). However, in fact, the entropy in the universe is quite low, indicating that it has not existed for an infinite amount of time.

I.B.2.
The Improbability of Indefinite Oscillations

If the universe has only been expanding and its volume is finite, then the universe has existed for only a finite amount of time. As will be shown below, this is very probably the case. However, if the universe has not been "solely expanding," then it must have been oscillating (expanding, then contracting, then re-expanding, etc.), for it is expanding at the present time. Therefore, if it can be shown that an infinite number of oscillations is highly improbable, then the universe's past time would have to be finite. There are two indications of the improbability of indefinite universal oscillation:

1) the radiation paradox,
2) an increase in cyclic expansion

1) The Radiation Paradox. Every expansion (i.e., explosion of the universe) would produce an immense amount of radiation. Since this radiation is approaching thermodynamic equilibrium, it can be expected to remain throughout each contraction and re-expansion. Therefore, if the universe has oscillated an infinite number of times, there should be an infinite amount of residual radiation in the universe. This is clearly not the case. Even the naturalist, Quentin Smith admits:

> The inference to a finite past can also be made from a measure of the amount of radiation present in the universe; if there were an infinite number of previous cycles, an infinite amount of radiation would be present in the current cycle, but the amount measure is finite.[26]

2) Increase in Cyclic Expansion. The second piece of evidence militating against an indefinitely oscillating universe is related to the first. If each cycle inevitably leads to increased radiation, then that radiation will cause increased pressure. This increased pressure, in turn, will make each cycle longer, giving rise to more cubic volume of the universe before a collapse. If the universe has existed through an infinite number of oscillations, then there should be an infinite amount of radiation leading to an infinite amount of pressure, leading to an infinitely long cycle producing an infinitely large universe. This is clearly not the case. The observable universe, though very large, has a very finite volume, indicating a very finite age of approximately 13.7 billion years.

Quentin Smith looks at the problem from the opposite direction, but arrives (even as a naturalist) at the same conclusion:

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[26] Smith 1993(a), pp. 112-13. See also, Silk 1980, p. 311.

> Radiation from previous cycles accumulates in each new cycle, and the accompanying increase in pressure causes the new cycle to be longer than the last one; the universe expands to a greater radius and takes a longer time to complete the cycle. This disallows an infinite regress into the past, for a regress will eventually arrive at a cycle that is infinitely short and a radius that is infinitely small; this cycle, or the beginning of some cycle with values approaching the values of this cycle, will count as the beginning of the oscillating universe.[27]

If one excludes the possibility of a *deus ex machina* (God surreptitiously removing all of the radiation from previous cycles, or the universe violating the first law of thermodynamics and allowing for the complete annihilation – nothingness – of previously existing matter), an infinitely oscillating universe seems to contradict the current condition of the observable universe.

I.B.3.

A "Solely Expanding" Universe According to *Classical* Big Bang Cosmology

As noted above, both contemporary and classical Big Bang cosmology invariably entail a "solely expanding" universe. The difference between the two versions of Big Bang cosmology arises out of the currently recognized probability of dominant vacuum energy causing universal acceleration or inflation.[28] Classical treatments of Big Bang cosmology usually include only matter and radiation. As will be shown below, if vacuum energy is not included, then there is not enough baryonic and non-baryonic matter to close the universe. If vacuum energy is included, then the very large pressure accompanying it will require that the universe be "solely expanding," even if it is in a closed configuration.

Since the existence of this vacuum energy is contested by some, I will present the argument for a solely expanding universe from both:

1) the classical model (accounting only for baryonic and non-baryonic matter),
2) the contemporary model (which includes vacuum energy, or something similar like quintessence, in addition to baryonic and non-baryonic matter).

Gott, Gunn, Schramm, Tinsley, Sandage, and Tammann have compiled striking evidence between 1970 to 1980 for a solely expanding observable universe. Their calculation is based on the following line of thought. According to the *classical Big Bang model*, the total mass-energy density of the observable universe will determine whether the universe is open (will continue to expand unendingly) or closed (will implode very probably into something like a black hole). If the average mass per unit volume, or mass density, is currently large enough ($5x10^{-30}$ grams per cubic cm – the so-called "critical density"), then the universe will be closed and will likely collapse. But if the average mass density is less then the critical density, the expansion of the universe will be able to run away from gravitational attraction. As the universe continues to expand, gravitational attraction becomes weaker and it can never slow the universe down to a halt. The universe will, therefore, continue to expand forever. Gott et. al. show (through the

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[27] Smith 1993(a), p. 112.

[28] See Linde, 1998, pp. 98-104.

assumptions of the classical Big Bang model) from three distinct tests that the universe is most probably open.[29]

(1) One can try to determine the deceleration parameter of the universe (q_0). Estimates of this can be made by comparing the redshifts of remote galaxies. This deceleration parameter gives an indication of the mass density of the observable universe which can then be compared to the critical density to determine whether the universe is open or closed. Current measurements suggest that the universe's actual average density is less than the critical density,[30] meaning that the universe is likely to be open.

(2) Estimates can be made about the average density of the observable universe from the mass density of all its galaxies. If we assume that the entire mass of the universe is contained within its galaxies, then the mass density of the universe is far too small to be closed.[31] As Craig notes, there are two methods for determining this. First,

> one may count the galaxies in a given volume of space, multiply by the masses of the galaxies, and divide by the volume…. [I]f all the mass in the universe is associated with galaxies then Ω can be only about 0.04, and the universe is definitely open.[32]

Secondly, as Craig notes,

> One may compare the behaviour of distant galaxies with the behaviour of those in the local supercluster of galaxies…. [I]f Ω is large, there ought to be a significant difference [between them]. In fact, the difference is undetectable. Therefore, Ω must be very small, no larger than 0.1. These estimates indicate that the galaxies themselves cannot close the universe.[33]

(3) Assuming that the vast majority of deuterium arose out of cosmogenesis, then one could determine the average mass density of the universe by examining the ratio of deuterium to helium.

Deuterium manifests an incomplete fusion process (since it takes longer to fuse helium with its extra proton and neutron). If the universe were expanding rapidly, many such incomplete fusion processes could be expected to occur. Thus, the ratio of deuterium and helium-3 to helium-4 should indicate the velocity of the expansion, which, in turn, would reveal the amount of gravity present during the expansion, which would, in turn, reveal the mass-energy density in the universe. Current measurements of this ratio indicate a mass-energy density considerably less than that required to close the universe.[34]

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[29] I will use William Lane Craig's synopsis of the work of Gott, Gunn, Schramm, Tinsley, Sandage, and Tammann to explicate this evidence. See Craig 1993(a), pp. 48-57.

[30] Craig, interpreting Gott, Gunn, Schramm, and Tinsley, gives a precise calculation of this in 1993(a), p.49. See also, Gott, Gunn, Schramm and Tinsley 1974).

[31] Craig explains why it is quite likely that the vast majority of mass is contained within galaxies and not in a deep space medium. See Craig 1993(a), p. 51; and Gott, Gunn, Schramm, and Tinsley 1974.

[32] Craig 1993(a), p. 50.

[33] Ibid.

[34] A precise calculation may be found in Craig 1993(a), p. 51. See also, Pasachoff and Fowler 1974, pp. 108-18.

These three pieces of independent evidence indicate an average mass density of the universe (according to the classical Big Bang model) well below what would be required to cause a universal collapse. Therefore, according to these assumptions, the universe would appear to be open, the oscillating universe hypothesis invalid, and the age of the observable universe to be approximately 13.7 billion years old.

II.

The *Contemporary* Big Bang Model

As noted in the introduction to this paper, several recent developments in astrophysics have made the contemporary Big Bang model more complex. Four of the more important developments are:

1) the probability of an inflationary era,
2) the vacuum energy intrinsic to that era,
3) difficulties with the singularity hypothesis, and
4) the possibility of a pre-Big-Bang unified era.

These developments have added considerable complexity to what is now known as the "contemporary Big Bang model" which makes the insight into a creation event less direct, but makes the insight into universal design more probative and beautiful.

II.A.

The Evidence and Effects of Inflation and Vacuum Energy

The contemporary Big Bang model may be discussed in four parts: 1) the evidence for an inflationary era, 2) the effects of vacuum energy (required to produce an inflationary period) on a solely expanding universe, 3) the potentiality for a pre-Big-Bang universe as suggested by the presence of vacuum energy, and 4) the possibility of a pre-inflationary universe.

1) The evidence for an inflationary period. Contemporary astrophysicists have gathered significant evidence for an inflationary period at the inception of the universe. In brief, evidence from the Hubble telescope, the COBE satellite, and consequent computer modeling of the universe seems to indicate that the universe would have had to have gone through an inflationary or super-accelerating period (caused by the presence of vacuum energy) in order to arrive at its current state.

Andrei Linde details four pieces of physical evidence in favor of an inflationary period near the origin of the universe:[35]

a) A period of extremely rapid inflation predicts density perturbations affecting the distribution of matter in the universe. These predictions may be verified by the

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[35] Linde actually gives six pieces of evidence, but as will be discussed below, two of them are metaphysical (Linde 1998, pp. 98-104).

distribution of galaxies. Currently, galactic distribution resembles what would have been predicted by an inflationary scenario rather than a classical Big Bang model, which cannot explain this at all.

b) The above density perturbations also imply slight variations in the large scale uniform cosmic radiation. Thus, the temperature of the cosmic background radiation should vary slightly over large areas. This variation in the radiation was not discovered before 1992 because the variation was so slight compared with its large scale uniformity. However, in 1992, the Cosmic Background Explorer satellite (COBE) began to show evidence of this. There is still work to be done in confirming these “ripples in space,” but as of the present moment, the COBE satellite, and other extensive studies of the cosmic microwave background radiation, have not been able to disprove inflation.

c) Inflationary theory is the only one that will allow for either a “flat universe” or a large, homogeneous, open universe. Since these two scenarios are currently more explicative of universal conditions than the closed one, it would seem that inflationary theory is necessary to explain our universe.

d) Under a standard GTR assumption, the physics of the early universe entails phase transitions which would have, as their consequence, unusually heavy particles like monopoles. Such heavy particles should be easily detectable. Up to this point, no such particles have been discovered.

Some physicists believe that an inflationary condition exists even today. This current mild inflationary period followed a period of deceleration which occurred until the era marked by a redshift of approximately 0.5.

2) Vacuum energy and a solely expanding universe. The occurrence of this inflationary (accelerating) universe is attributable to the effects of vacuum energy which negatively interacts with density and has a strong pressure associated with it. Current evidence suggests that this pressure exceeds the gravitational attraction induced by the vacuum energy, causing an overall acceleration in the expansion of the universe.

Recall that vacuum energy is evidenced in the “borrowing” of energy for virtual particle pair creation within a quantum system. It is different from mass energy in that it opposes gravity and actually increases in magnitude with distance. When Linde and others discovered the probability of an inflationary era, they also pointed to the probable existence of vacuum energy in the universe as a whole (in addition to the vacuum energy in quantum systems) to induce this inflation.

Alan Guth has elucidated some of the stages which are likely to have occurred at the inception of inflation:

> [a] a patch of [a special] form of matter [creating gravitational repulsion at high energies] existed in the early universe – it was probably more than a billion times smaller than a single proton! The gravitational repulsion created by this material

> was the driving force behind the big bang. The repulsion drove it into exponential expansion, doubling in size every 10^{-37} second or so!
>
> [b]The repulsive-gravity material is unstable, so it decayed like a radioactive substance, ending inflation. The decay released energy, which produced ordinary particles, forming a hot, dense "primordial soup." Inflation lasted maybe 10^{-35} second. At the end, the region destined to become the presently observed universe was about the size of a marble.
>
> [c] The "primordial soup" matches the assumed starting point of the standard big bang—the standard big bang description takes over. The region continues to expand and cool to the present day.[36]

If this is correct, then the universe would be solely expanding (in either a flat or open configuration) and the calculations showing an open universe (according to the assumptions of the classical Big Bang model) would be unnecessary. This abandonment of *classical* calculations, however, does not affect the fact that the universe has been "solely expanding," because the outward pressure produced by the vacuum energy would prevent such an accelerating universe from collapsing in upon itself even if it were in a flat (just between open and closed), or even in a barely closed, configuration.[37] Therefore, the assumption of vacuum energy in the contemporary Big Bang model requires that the universe be "solely expanding."

3) Linde and Guth on regional inflation. Andre Linde has proposed a model to explain the transition from the universe's initial state to its inflationary era. He gives a chaotic, fractal-like twist to traditional inflationary theory.[38] The theory is premised on the notion of scalar fields which mediate the interaction between electromagnetic and weak forces:

> If a scalar field interacts with the W and Z particles, they become heavy. Particles that do not interact with the scalar field, such as photons, remain light.[39]

Linde adapts this notion of scalar fields to the universe as a whole and shows how it could explain inflationary regions by various scalar fields having arbitrarily different values in different regions ("chaotic" – "fractal-like" inflation). This obviates the need for phase transitions, super-cooling, or even the standard assumption that the universe originally was hot, which complicated earlier models of inflationary theory.[40] For Linde, scalar fields can take on arbitrary values in the early universe. Some of these values will result in the universe expanding quite rapidly while others result in very little expansion.

Using chaotic inflation as a base (where different regions can have incredibly different volumes), he conjectures that each inflationary region can produce new regions (like the multiplication of a fractal):

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[36] Guth 2003.

[37] These different configurations affect the view of spatial sectioning within the observable universe, but do not affect the probability of a finite age of the universe implied by a universe which has only been expanding, and has expanded to only a finite volume.

[38] See Linde 1998 and 1994, and Guth 1997.

[39] Linde 1998, p. 101.

[40] Ibid., p. 102.

> From this it follows that if the universe contains at least one inflationary domain of a sufficiently large size, it begins unceasingly producing new inflationary domains. Inflation in each particular point may end quickly, but many other places will continue to expand. The total volume of all these domains will grow without end. In essence, one inflationary universe sprouts other inflationary bubbles, which in turn produce other inflationary bubbles.[41]

He then makes recourse to multiple singularities expressing temporal beginnings and ends of specific regions of the universe:

> Each particular part of the universe may stem from a singularity somewhere in the past, and it may end up in a singularity somewhere in the future…. The situation with the very beginning is less certain. There is a chance that all parts of the universe were created simultaneously in an initial big bang singularity. The necessity of this assumption, however, is no longer obvious.[42]

Alan Guth and others have explored Linde's conjecture and have concluded to the *possibility* of eternal inflation into the future, *but not into the past*. Notice that this does not conflict with Hilbert's prohibition of an infinite past because future eternity is merely a potential infinity (in Hilbert's parlance) which *can* keep on going into the future, but is only *finite* at any given present moment. Thus, "eternal inflation" does not imply an achieved infinite series, but only a potentially infinite – indefinite – series. Though Guth does not make recourse to Hilbert's prohibition or ontological analysis, he indicates skepticism about inflation proceeding infinitely back in the past on the basis of physics (the inevitability of a singularity in any known model):

> Since inflation is eternal into the future, it is natural to ask if it might also be eternal into the past. The explicit models that have been constructed are eternal only into the future and not into the past, but that does not show whether or not it is possible for inflation to be eternal into the past. Borde & Vilenkin (1994) presented a proof that an eternally inflating spacetime must start from an initial singularity, and hence must have a beginning, but later they pointed out (1997) that their proof assumed a condition that is true classically but is violated by quantum field theories. Today the issue is undecided. My own suspicion is that eternally inflating spacetimes must have initial singularities, because it seems significant that no one has been able to construct a model which does not.[43]

How, then, did inflation begin? This question is likewise unresolved, but is open to String Theory and quantum cosmological inceptions of inflation:

> There is even more uncertainty about what happened before inflation, and how inflation began. .... Most likely, however, inflation can be eternal only into the future, but still must have a beginning.[44]

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[41] Ibid., p. 103.
[42] Ibid., p. 105.
[43] Guth 2001, p. 12.
[44] Guth 2001, p.1.

Though Linde's and Guth's theories do not explain the inception of inflation, they indicate the likelihood of a beginning of inflation and are open to quantum cosmological and String Theory as possible explanatory models.

If Guth's suspicions are correct, then the inflationary universe (having either multiple regions or only our own) could have begun with either (1) an initial inflationary moment, or (2) a pre-inflationary unified state (perhaps describable by quantum cosmology and/or String Theory). If the first option is true, then the beginning of inflation is the beginning of the universe (approximately 13.7 billion years ago). If the second option is true, then the likely beginning of the pre-inflationary Planck era would constitute the beginning of the universe. The following will clarify this.

4) The possibility of a pre-inflationary universe (a Planck era). Recall that in the standard GTR model, electromagnetic, strong nuclear, and weak forces interact with gravity through the curvature of a dynamical space-time field. But this cannot be the case in a Planck era because the units of space are too small (less than or equal to the Planck minimum of 10^{-33} cm). Nevertheless, gravity is dominant in this era in a quantized form. (At low energies, it must be consistent with GTR). This unification of gravity entails a form of time considerably different from the one described in the standard GTR model.[45] The extreme and unusual conditions which might have constituted such an era are briefly (and speculatively) described in Section II.C through quantum cosmology[46] and String Theory. This era could have had a long duration and could have been conditioned by a highly irregular quantum cosmological temporality. As will be shown below (II.B.), this highly unusual form of time would still entail an asymmetrical relation of events, and would not permit backward causation or time reversal.

In sum, if option #1 were true (post-Big-Bang universe only), and Guth's conjecture that inflation must begin with a singularity is also true, then physics will have already demonstrated that the universe is finite in age (approximately 13.7 billion years old). Option #2 (pre-Big-Bang unified era), though more speculative, allows physical evidence to show a *likelihood* of finite age. If both options require (at least probabilistically) a finite age of the universe, they will also require a causative power transcending space-time asymmetry.

II.B.
An Ontology of Space and Time

Before investigating quantum cosmological and String Theory conceptions of a totally unified era, it may prove helpful to give a brief *ontological* explanation of proto-time. The physics of time in a totally unified era is very incomplete, which has led many to speculate about imaginary time, symmetrical time, backward causation, and other unusual variations of event asymmetry. Thus, it seemed appropriate to present an ontological explanation of time which

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[45] Note that the inflationary era which follows from the unified era does not violate GTR. Indeed, it is an allowed solution of the GTR field equations for a vacuum energy dominated universe. However, the time asymmetry intrinsic to the unified era would have to be quite different from that in the GTR era.

[46] The quantum path integral, calculated by Richard Feynman through a "sum over histories" method, has been used to *mathematically* integrate the three *non*-gravitational forces. Stephen Hawking and others have made an ingenious adaptation of this to integrate gravitational forces into the other three (see below, IV.B.1). Others have used string supersymmetries, and fractal-like scalar fields to unify the four forces (see below, IV.B.2 through 3).

shows the natural asymmetry of events wherever there is change or changability (including unified fields, string conditions, quantum cosmological conditions. and other variants of the GTR model).

Ontological method may seem quite foreign to physicists and other non-philosophers. Though ontology does not derive its data directly from the empirical world, it does try to establish the *necessary* conditions and parameters of contingent existence (i.e., changeable existence, which includes physical existence). As such, it could reveal some necessary properties even of an unknown totally unified era. It must be stressed that the ontological time discussed below is not absolute. Its conditions and parameters allow for tremendous quantitative and qualitative variance. It is therefore compatible with any cosmological model of time which admits its broad ontological parameters. One of these parameters, as will be seen, is the asymmetry of transitions that occur through it.

Brevity constrains me to summarize my much more extensive investigations of this matter. Interested readers may wish to make recourse to them.[47]

Ontological explanations are different from descriptions and scientific explanations. Descriptions relate data to an observer (e.g., the sun is rising). Scientific explanations relate data to other data through qualitative and quantitative apparatuses (e.g., the earth is rotating on its axis and is orbiting around the sun). Obviously, true descriptions can be false explanations. Ontological explanation is distinct from scientific explanation because it relates data to necessary conditions rather than relating data to data. Thus, the question for ontology is, "What are the conditions *necessary* for the *possibility* of…?"[48]

When Aristotle and Zeno were asked to define motion, they did it in terms of its two necessary conditions, namely space and time. When they were asked to define space and time they did it in the same way, which involved magnitudes (divisible unities). Divisibility evidently entails separation; not complete separation, but rather intrinsically unified separation (in contrast to, say, two discrete points).

II. B.1

An Ontology of Space

Let us begin with "space."[49] This ontological discussion is important to astrophysics because some physicists and astronomers have theorized about the possibility of an infinite amount of space in a hypothetical non-observable universe. Inasmuch as the "non-observable universe" is non-observable, physics cannot empirically prove or disprove this conjecture. Hence, I must make recourse to ontological methodology to determine whether such conjectures are intrinsically contradictory.

Physicists have also theorized about the possibility of a *really* infinitely divisible spatial continuum. Again, such a conjecture could not be empirically verified without an empirical test

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[47] Spitzer 2000, pp. 260-276. See also Spitzer 1989.

[48] See Spitzer 2000, pp. 261-264.

[49] An ontological definition of time will be given below (IV.A.) and hence, I will restrict myself here to an ontological definition of space. I have elsewhere given an extensive ontological definition of space, so I will here be quite brief. See Spitzer 1989, pp.109-158.

of infinite division. Such a test is probably a long way off! Hence, I am again constrained to use ontological method to test for intrinsic contradictions.

The ontological response to the above two conjectures can help astrophysicists (non-empirical, non-mathematical way) to formulate notions of "pre-space," "proto-space," and "spatiality" which seem to be abundant in many contemporary cosmological theories.

1) An ontological definition "space."

First, space is not nothing. There cannot be "more or less" of nothing as there can be "more or less" of space. Nothing is simply nothing. As will be seen below, nothing is not continuous, dimensional, connectable, or orientable. Yet space in the observable universe has all four of these characteristics.[50]

If space is not nothing, then what is it? Let us begin with locomotion. Locomotion entails displacement (i.e., a change in place). Displacement, in turn, entails distinct yet unified places. "Distinct yet unified places" entails: 1) contemporaneous separation of those places, and 2) intrinsic unity of those contemporaneously separated places. Were there no unity between contemporaneously separated places, there would be no possibility of moving from one to the other. Completely disunified places preclude motion.

This intrinsic unity of contemporaneously separated places constitutes the most fundamental quality of space, namely, continuity. Continuity, in turn, is the condition necessary for the possibility of the other three characteristics of space in our observable universe, namely dimensionality, connectivity, and orientability.

[51]Let us return for a moment to the discussion of constituent parts. Continuous space cannot be really divided into infinitely small parts (such as Euclidean points), for such parts would not be constitutive of the whole magnitude.[52] If space were divisible into infinitely small parts,[53] they would not be constitutive of it, for an infinite number of them could be added or subtracted from the whole without any *real* effect.[54] Therefore, there must be a *finitely* small minimum magnitude of space. Though space is theoretically divisible *ad infinitum* (a *potential* infinity in Hilbert's parlance) it cannot be *really* divided into infinitely small constituent parts.

This is why Euclid defined a point as "position without magnitude." The absence of magnitude makes a point ineligible for the status of "constituent part" (whose addition or

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[50] See Davies 1977, pp.5-11.

[51] Paul Davies speaks of these three qualities of space in our observable universe *Space and Time in the Modern Universe* (Davies, 1977,pp. 1-27).

[52] As Euclid noted long ago, points have position but no magnitude.

[53] The typical definition of "infinitesimal" as "infinitely small, but greater than zero" is a contradiction. If something is truly infinitely small, then it should be able to be added to itself an infinite number of times without increasing the total. Furthermore, one should be able to subtract an infinite number of infinitely small parts from a finite segment without reducing the whole. This simply cannot be done with any non-zero magnitude. If one were to subtract any non-zero magnitude (no matter how small) from a finite segment, it would reduce the size of the segment. And if one were to add any non-zero magnitude to itself any number of times, it would increase the total. In short, the common definition of infinitesimal is "having one's cake and eating it too." If something is "infinitely small" in the way indicated above, then it is equivalent to zero, and if it is infinitely small with any non-zero magnitude, then it is really finitely small. (See Spitzer 1989, pp. 90-99, which also contains an Hilbertian argument against infinitely small minimum units of duration.)

[54] See Spitzer 1989, pp.81-88

subtraction really affects the whole). Points are therefore relegated to the status of “position” alone. Inasmuch as space can only be divided into finitely small (non-zero) constituent parts, it must be susceptible to metrical and geometrical measurement.

Unlike physics, ontology is not concerned with the *specific* quantity of the above-mentioned “finitely small minimum” of space. Ontology can only prove that there must be such a minimum. This finitely small spatial minimum should manifest itself in observable, testable ways. Though the Planck minimum of space (10^{-33}cm) may seem to fit the requirements for this spatial minimum, one must be quite careful about jumping to conclusions. Particular spatial minimums do not have to be universal. They could vary from region to region or even from situation to situation. Ontology holds only that there be *some* finitely small minimum; the specific quantity of that finitely small minimum is beyond its capability to demonstrate. The same holds true for the dimensionality, connectibility, and orientability of space. There is no necessity (from the vantage point of ontological demonstration) for any particular metric, geometric, or geodesic to be actual in any real universe.

In sum, the “conditions necessary for the possibility of *space”*(which might be termed “proto-space” or in the parlance of some physicists “pre-space” or “spatiality”) are (1) placement (different places at the same time—contemporaneous separation) and (2) displacement (which requires an intrinsic unity between contemporaneously separated places). This intrinsically unified contemporaneous separation must be constituted by finitely small minimum units.

2) An infinite amount of space is composed of non-constituent parts.

A “constituent part” is one whose addition or subtraction must affect the whole. But an infinite number of parts requires that the addition or subtraction of any finite number of parts (or any infinite subset of parts) *not* affect the whole. The postulation of infinite space in the non-observable universe is tantamount to postulating that space is constituted by an infinite number of parts. But this last postulation effectively reduces each part to the status of an infinitesimal (e.g., a zero magnitude) which, by nature, cannot be constituent.

From an ontological point of view, then, any hypothetical conception of a non-observable must be finite in space, because:

1) An infinite spatial magnitude reduces all its parts to non-constituent parts,
2) But the parts of any continuous space must be constituent parts having a finitely small (non-zero) minimum.

Therefore continuous space and infinite magnitude are contradictory.

Continuous Space	is Infinite
constituent parts	non-constituent parts

Though this ontological point of view may seem somewhat dissatisfying to physicists, it does have the advantage of being able to probe observationally inaccessible domains through its method of "conditions necessary for the possibility of…." It may even have certain predictable (empirically accessible) outcomes, such as a finitely small minimum magnitude of space. Testing for these empirical characteristics, however, is difficult, because ontology does not have access to the precise quantities with which these characteristics are associated.

If the above ontological analysis is valid, then the space of the non-observable universe must be finite. This brings with it a host of new difficulties. Shouldn't there be something beyond the non-observable universe? How can the end of the non-observable universe be explained? Does nothing literally lie beyond it? At this juncture, one is almost inevitably plunged into the domain of metaphysics. Perhaps the metaphysical responses needed for the above questions will coincide with the conclusions given at the end of this paper.

II.B.2

An Ontology of Time

We may now turn to an ontology of *time*. This discussion may prove helpful to astrophysicists because time in a hypothetical *pre-Big-Bang* universe would have to be highly unusual (given the dominance of gravity in a quantized form, and its unification with the other three universal forces). This has led some cosmologists to speculate that this "pre-Big-Bang" time could be symmetrical (i.e., could go backward or forward).[55] This conjecture could present challenges to a finite age of the universe. However, as the following ontology will show, time (in its fundamental nature) supports only asymmetrical event structures (without the help of a "*deus ex machina*") and is therefore asymmetrical in any conception of a pre-Big-Bang universe (even with its highly unusual temporal conditions).

Recall that scientific explanation seeks to relate data to data while ontological explanation relates data to the conditions necessary for its possibility. Five germane points will be briefly discussed:

1) existential non-coincidence,
2) unity of existential non-coincidence,
3) the limiting condition of existence,
4) asymmetry and ontological time, and
5) manifestations of ontological time.

1) Existential non-coincidence. It is perhaps best to begin our ontological analysis of time without making recourse to locomotion (which combines space and time). This may be done by looking at a non-spatial change such as death. Let us suppose a cat dies. One of the most apparent ontological truths about this occurrence is that "the state before" and "the state after" cannot be coincident. If they were, it would be an obvious contradiction (the cat simultaneously alive and dead). This, of course, is the problem with all history. Changed existential states cannot be coincident without contradiction. Therefore, wherever there is change, indeed, wherever there is changeability, there must also be some existential non-coincidence which

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[55] See, for example, Hawking's proposal in *Brief History of Time* (Hawking 1988, pp. 132-145). See below, Section II.C.1 on Hawking's use of imaginary numbers in Feynman's "Sum Over History's" Method.

allows differing states to occur within a single entity (e.g., a cat). Let us sum up this initial definition of time as "the existential non-coincidence necessary for the possibility of changed states within a single entity." Another way of looking at it is, "that without which all history is a contradiction." If this "that without which…" were not objectively real, changeable beings would be impossible (i.e., all change would be a contradiction).

2) Unity of existential non-coincidence. At this point, one will want to ask, "What is 'existential non-coincidence?'" or "How does it manifest itself?" The temptation here is to spatialize it, by, for example, inserting a spatial continuum between "the cat alive" and "the cat dead." Though this may be very satisfying from the vantage point of human imagination, it leads to a host of problems. To begin with, our cat both alive and dead is in the same place, and the separation of its existential states is not describable by an extensive separation. Yet, the cat's change does require a non-extensive separation (frequently termed "a distensive separation"). One must be careful here not to visualize distensive separation as a three-dimensional continuum, otherwise one will be imposing a quasi-spatial continuum between events.

Henri Bergson wrestled with this problem, and finally made recourse to a kind of "protomentalist unified separation of existential states" which he termed "elementary memory." He supposed that this elementary memory existed in the universe as a whole, as a kind of very "elementary cosmic consciousness." In a famous passage in *Duration and Simultaneity*, he noted:

> What we wish to establish is that we cannot speak of a reality which endures without inserting consciousness into it.[56]

In order to show this, he constructs a thought experiment in which he assumes the above existential non-coincidence of incompatible states:

> We shall have to consider a moment in the unfolding of the universe, that is, a snapshot that exists independently of any consciousness, then we shall try conjointly to summon another moment brought as close as possible to the first, and thus have a minimum amount of time enter into the world without allowing the faintest glimmer of memory to go with it. We shall see that this is impossible. Without an elementary memory that connects the two moments, there will be only one or the other, consequently a single instant, no before and after, no succession, no time.[57]

I do not wish here to affirm Bergson's protomentalist conclusions, but I do want to acknowledge the ontological conditions of change and time which Bergson recognized in concluding to them, namely,

1) a real existential non-coincidence between changed states,
2) a fundamental unity within this separation which unifies the non-coincidence of before and after, and
3) the non-spatial (and hence, for Bergson, the mnemonic) character of this "unity of existential non-coincidence."

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[56] Bergson 1965, p. 48. See also Spitzer 1989, pp. 12-14.

[57] *Ibid*.

These three ontological conditions now give a further refinement of our ontological explanation of time, namely, "a non-spatial unity intrinsic to existential non-coincidence necessary for changeability."

3) The limiting condition of existence. The question now arises, "What is this unity of existential non-coincidence?" Ontological explanation tries to answer this question by making recourse to more fundamental principles of reality. Bergson thinks he has located one such principle in his notion of "elementary memory" or "elementary consciousness." The more common approach has been to make recourse to "existence" or "being" (which is considered to be more fundamental than time). The constraints of this paper do not permit me to go into a complete explanation of this most fundamental principle, so I will give only two points and refer the reader to quite lengthy explanations in my other works:[58]

> **a) "Existence."** Existence is not brute facticity. It is the dynamic property which ultimately fulfills the conditions of a conditioned being. Cats, for example, are conditioned beings. Their existence depends on the fulfillment of conditions (such as, cells and structures of cells). These cells, in turn, are also conditioned beings dependent on the fulfillment of still more fundamental conditions (such as, molecules and structures of molecules), which are, in turn, dependent upon still more fundamental conditions (such as atoms…) which are, in turn, dependent upon more fundamental subatomic particles…etc. Thus, "a conditioned being" may be defined as "a being whose existence is *dependent* on the fulfillment of conditions." These conditions could be states, fields, structures, positions, space-time configurations, quantum information – whatever is needed for the existence of another real condition or state. A "cause" will be defined as the *proximate* fulfillment of any conditioned being's conditions. "Existence" will be defined as "the *ultimate* fulfillment of a conditioned being's conditions by an *unconditioned* being." An unconditioned being is one which does not depend on the fulfillment of any conditions for its existence. The following consideration makes this clear.
>
> An infinite number of causes which are conditioned beings (i.e., dependent on the fulfillment of conditions for their existence) is existentially equivalent to nothing. Since each cause is equivalent to nothing without its conditions being fulfilled, and since all these causes are hypothesized to be such, then all of them are dependent on conditions which are not yet greater than nothing. Thus, in their totality, they are nothing. Therefore, there must be at least one unconditioned being which can fulfill the conditions of conditioned beings without depending on any conditions being fulfilled. Since an unconditioned being exists of itself, it is, as it were, "greater than nothing" of itself. Such a being, therefore, can be, and indeed must be, the *ultimate* fulfillment of the conditions of any conditioned being (or group of conditioned beings).
>
> In sum, if every conditioned being depends for its existence on conditions being fulfilled, and an infinite number of conditioned beings is equivalent to nothing without at least one unconditioned being, then every conditioned being must have its conditions *ultimately* fulfilled by an unconditioned being. This ultimate fulfillment of conditions could go through hundreds of thousands of steps (e.g., atoms → protons → quarks →…→ unconditioned

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[58] See Spitzer 2000, pp. 268-276 and 1989, pp. 60-90.

being). This "ultimate fulfillment of a conditioned being's conditions by an unconditioned being" is precisely what is meant by "existence."

b) "Ontological time." Since a conditioned being can cease to exist, its conditions are not fulfilled unqualifiedly and absolutely. Thus, its existence (the ultimate fulfillment conditions by an unconditioned being) must have a qualification or limiting condition intrinsic to it. I would submit that time is this intrinsic, limiting condition of a conditioned being's existence. Though time may at first seem to be "positive" (a unity of existential non-coincidence), it really emerges as a "negative," that is, a limiting condition of ultimate positivity (i.e., existence). Ontological time may now be defined as "the unity of existential non-coincidence arising out of the intrinsic limiting condition of a conditioned being's existence."

4) Asymmetry and ontological time. Before discussing asymmetry, it should be noted that ontological time cannot be a motion. Inasmuch as motion has not only spatial displacement, but also temporal displacement ($\Delta D/\Delta T$), ontological time cannot be a motion, for if it were, this motion would itself have to have a temporal component, which temporal component would be a motion, which would in its turn have to have a temporal component… constituting an infinite regress. We must therefore stay close to the above definition, namely, that time is a limiting condition of existence.

In what sense, then, can we consider time to be asymmetrical? Inasmuch as time is not spatial (like an arrow) nor a motion (with a particular direction) we cannot say that the limiting condition of existence is asymmetrical, but we can say that the transition of contingent states of affairs conditioned by time is asymmetrical. Thus, once transitions have been made, one cannot go back to the earlier state as it *was*[59] because that earlier state no longer exists. It has been replaced by the later state. The only way of returning to the earlier state as it *was* (going back in time) is to subscribe to something akin to Bergson's cosmic elementary memory. If such a memory existed, and remembered all past states that have transitioned through the unity of non-coincidence, and held all these states in a sequenced form exactly as they occurred prior to the transition, then that cosmic elementary memory might be able to take an entity from a later memory and put it back into an earlier memory. But paradoxes continue to abound.

First, there is the problem of a later entity being put into an earlier moment "as it was." The moment the later entity arrives in the earlier, the earlier is no longer "as it was." Furthermore, this possibility gives rise to a host of irresolvable paradoxes. Davies gives one example:

> One could then construct a booby-trapped device which could destroy itself by a coded signal sent into the past, thereby removing the possibility of sending the signal in the first place – an obvious contradiction![60]

From an ontological point of view, then, it must be said that even though time is not asymmetrical, the condition which ontological time permits (namely, passing out of existence and coming into existence; conditions ceasing to be fulfilled and new conditions being fulfilled) *is* asymmetrical because past states of affairs no longer exist (unless there really is some kind of

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[59] One, of course, can move to a state similar to an earlier state, but this does not mean that one is going back in time, that is, returning to the earlier state itself, for that earlier state no longer exists.

[60] Davies 1977, p. 47.

cosmic consciousness similar to the one mentioned above). We can therefore say time is not asymmetrical, but any state of affairs conditioned by time is asymmetrical.

5) Manifestations of ontological time. The "unity of existential non-coincidence" must be measurable, because it cannot be an instant (a dimensionless point) or an infinitesimal (which functions like a dimensionless point[61]). As Bergson noticed, an instant will not suffice to separate two existential states in the same being (e.g., the cat alive and dead). Thus, the unity of existential non-coincidence must be finitely small, and therefore be measurable. As I show in my dissertation,[62] this finitely small interval of duration (to borrow Bergson's word) gives rise to some predictable factors within any contingent universe (including ours):

a) There would have to be a finitely small minimum interval of time in order for change to occur. Change would not be able to occur in any time interval less than this. From the vantage point of ontology, any particular quantity for minimum time is arbitrary. Hence, one cannot say that Planck time (10^{-43} seconds), which seems to be a minimum for certain kinds of change in this universe, would have to be such a minimum in any other universe. Furthermore, this minimum may only be applicable to certain kinds of change within the universe, while another number may be applicable to other kinds of change in the universe.[63]

b) Moreover, a minimum interval of time predicts a maximum possible velocity (because no specific distance could be traversed in any less time than the minimum possible interval). Stated differently, since spatial displacement cannot take place in zero seconds, infinite velocity is impossible. Therefore, maximum velocity must fall within a finite parameter. Though this prediction seems to resemble "**C**"(300,000kps), in our universe, ontological method cannot establish this, for such a quantity is not necessary, and therefore, requires empirical data and measurement. From the vantage point of ontology, then, there is no reason why a minimum unit of time, a minimum unit of space, or a maximum unit of velocity should have the same measure from place to place, entity to entity, or even time to time. Ontology requires only *that* there be *some* minimum or maximum parameters.

c) Minimum units of space and time would also delimit the way in which energy could be manifested. This would seem to suggest that energy be manifest in finitely small minimum thresholds (whose parameters are determined by minimum space and minimum time). This sounds similar to Planck's quantum theory, but again, ontology recognizes no particular quantity as being special or ingredient to these finitely small minimum thresholds.[64]

If the above conclusions are correct, then any changeable state of affairs would have to exist through ontological time (a finitely small minimum "unity of non-coincidence"). This limiting condition of contingent existence necessitates an asymmetry of change, a minimum unit of duration, a maximum allowable frequency or velocity of change, and a minimum threshold of the manifestation of energy. The quantities of such minimums and maximums are arbitrary from the

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[61] The typical definition of "infinitesimal" as "infinitely small, but greater than zero" is a contradiction.
[62] Spitzer 1989, pp. 60-105.
[63] Spitzer 1989, pp. 81-90.
[64] Spitzer 1989, pp. 207-224.

vantage point of ontology, but their existence along with that of ontological time would have to be present wherever changeable entities or states exist. This would evidently include any model of an initial unified field (in a pre-Big-Bang universe) which could transition into a GTR field.

The use of necessity and the lack of empirical measurement may make the above analysis unsatisfying to physicists. Nevertheless, it does predict the presence of proto-time and asymmetrical transitions in any hypothetical conception of an initial, unified era. If such a unified era can be shown to be finite in age, and the event structure intrinsic to it to be asymmetrical (i.e., cannot go backwards) then the universe itself would have to be finite in age, suggesting a causative force transcending space-time asymmetry.

II.C.
Two Non-Exclusive Theories of a Pre-Big-Bang Unified Era

As noted above, the inflationary era may have been preceded by an era in which the universe was in a super-unified condition. Though gravity is strongly interacting with the other three forces, it is not doing so through a standard GTR space-time field. Hence, an adequate description of this state will require gravity to interact with the other three universal forces in a super-unified way. This super-unity may make the four forces indistinguishable from one another, making its time asymmetry unusual by comparison with that described by standard GTR. Nevertheless, as explained above, there must be some kind of proto-time intrinsic to this unified field through which asymmetrical change occurs. Two non-mutually exclusive attempts have been made to broach this subject:

1) quantum cosmology[65] and
2) superstring theory approaches to quantum gravity/quantum[66]

Previous attempts to unify gravity with the other three universal forces have resulted in irresolvably paradoxical conditions (such as infinities being applied to algorithmically finite structures). These paradoxes forced physicists to account for this era of fundamental physical unity in highly theoretical ways. The above two approaches represent the best non-paradoxical, non-exclusive explanations for the unity of gravity with the other three forces.

II.C.1.
Quantum Cosmology and Hawking's "No Boundary Condition" Universe

Perhaps the most well-known proposal comes from Stephen Hawking in his popular work, *Brief History of Time*.[67] It is commonly referred to as the "no boundary condition" ("edgeless") universe. Since the time of Richard Feynman, mathematical integration of the electromagnetic, weak, and strong forces has been accomplished through the so-called "sum-over-histories" approach to path integrals.

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[65] See Callender and Huggett 2001, Hertog 1996, and Gibbons and Hawking 1993.
[66] See Greene 2000, Herdeiro 1996, and Davies and Brown 1988.
[67] Hawking 1988.

> The probability that a system in an initial state A will evolve to a final state B is given by adding up a contribution from every possible history of the system that starts in A and ends in B….[68]

In order to accomplish this, it is necessary to take the three spatial dimensions and one temporal dimension and convert them into four spatial dimensions. This, of course, only has a mathematical reality, for there are only three spatial dimensions, and reducing the time dimension to a spatial dimension requires the use of imaginary numbers.

The difficulty with this technique, as Hawking himself admits, is that:

> When one actually tries to perform these sums…one runs into severe technical problems. The only way around these is the following peculiar prescription: One must add up the waves for particle histories that are not in the "real" time that you and I experience but take place in what is called imaginary time. Imaginary time may sound like science fiction but it is in fact a well-defined mathematical *concept* (italics mine).[69]

The theoretical difficulties involved in integrating imaginary numbers into a real time scheme provoked researchers to propose another scheme of quantum cosmological integration giving priority to real path integrals (as distinct from imaginary ones). The theory of "instantons" (the rare geometries that give particularly large contributions to real as distinct from imaginary path integrals) could be a partial solution to the problem of ontologizing imaginary numbers.

One such proposal was formulated by Steven Coleman and Frank De Luccia based on their research into the possibility of false vacuums, which are quantum-mechanically unstable, though classically stable, excited states. Hertog points to several difficulties in using this conception of instantons.[70] Stephen Hawking and Neil Turok attempted to resolve some of these problems with a class of instantons that did not require the existence of "false vacuums" and tunneling, but this gave rise to other problems (such as multiple singularities).[71]

Three conclusions may be drawn at this juncture:

1) The current attempts to integrate gravity with the other three forces through a path integral method (whether this be Hawking's early pure form of it, or later forms which include instantons) are highly theoretical, incomplete, and contain theoretical difficulties manifest by absent parameters and singularities. This, however, does not mean that there is not validity to this model. We simply cannot know at this juncture where the validity may lie.

2) In view of (1), the physical-mathematical conception of time (intrinsic to both the model and any real manifestation of it) is virtually unknown. Therefore, one cannot make a

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[68] Hertog 1996, p. 2.
[69] Ibid., p. 134.
[70] Hertog 1996, pp. 3-4.
[71] Ibid., p. 5.

judgement about time asymmetry based on any such physical-mathematical conception. I would therefore submit that the ontological view of time proposed above be utilized until a more definite physical-mathematical one can be verified. The only requirement for applicability of the asymmetry intrinsic to ontological time is changeability of existence. This condition can surely be met with respect to a totally unified era because it transitions at a specific point to an inflationary condition. Furthermore, all the above models assume changeability whether these be manifest in the transition of states represented by path integrals, or tunneling from false to true vacuums.

3) If ontological time were present in a quantum cosmological, pre-Big-Bang unified era, and the transitions which occur through this ontological time were asymmetrical, then the age of this pre-Big-Bang era would be likely to have been finite (see the reasoning below in Section II.D).

II.C.2.
Superstring Theory Approaches to Quantum Cosmology

Another approach to the unified era (which does not exclude a quantum cosmological approach) may be found in superstring theory which integrates gravity with the other three forces of nature without implying infinities in algorithmically finite structures.[72]

String theory is a derivative of elementary particle theory. It views particles as extended one-dimensional, massless, "string-like" objects 10^{-33} cm long. These strings (whether open or closed) vibrate, and each kind of vibration corresponds to a particle type. Strings may interact with one another, giving rise to a wide variety of particle-like and energetic expressions. Superstring theory not only attempts to integrate the four forces, but also all the spins of all possible elementary particles. Hence, it finds symmetries between fermions (half integer spins) and bosons (full integer spins).

Though string theory holds out a possibility for theoretical explanation of total unification in the universe's initial state, it faces two major difficulties. First, it requires ten (and in M-theory, even eleven) dimensions for complete symmetrical integration. Secondly, five possible super / heterotic symmetries of strings instead of one seem to suggest a kind of arbitrariness in the whole theoretical apparatus.[73] Thus, superstring theory faces the same three challenges as the Hawking or instanton quantum cosmological theories:

1) It is highly theoretical and difficult to verify.

2) In view of (1), it will be difficult to construct a physical-mathematical model of time which can be applied to (let alone verified of) an initial string state of the universe.

3) Nevertheless, the changeability of string conditions (e.g., vibration and transition to an open inflationary state) requires that ontological proto-time asymmetry be intrinsic to it. If proto-time asymmetry is intrinsic to this pre-Big-Bang era, and it is likely that this

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[72] See Greene 2000, Herdeiro 1996, and Davies and Brown 1988.

[73] Herdeiro 1996.

unified era had temporal limits, then it is likely that the pre-Big-Bang universe (and the universe itself) would have to be finite in age.

II.D.
The Probable Finitude of a Pre-Bang-Bang Unified Era

The following five physical-ontological factors would seem to have been present in any model of a pre-Big-Bang unified era (quantum cosmological, string theory, or other) which transformed itself from a unified field to a GTR field (and an open inflationary state):

1) **A destabilizing or disunifying factor.** If there was a pre-Big Bang unified era, the unified field intrinsic to that era would have had to have undergone a radical transition into a GTR field (characterizing the post-Big Bang observable universe). This transition would have entailed a "de-quantization" of gravity and gravity's consequent metamorphosis into a GTR-like space-time field. Furthermore, the time and physics of the unified era would have been radically transformed into the time and physics of the observable universe. This transition could not have occurred without some destabilizing or disunifying factor intrinsic to the hypothetical unified field. If the unified field did not have such a disunifying factor, it would have remained in a stable state indefinitely (i.e., it would have never undergone a transition to a GTR-like state). This destabilizing or disunifying factor could be described in a variety of ways. It could have been a distant relative of vacuum energy or a scalar field; or perhaps something akin to a false vacuum or an entropic condition built into the unified state. It could have also been a breakdown in the unified state arising out of an increase in a non-GTR form of extentionality. Inasmuch as the pre-Big-Bang unified field is unknown, so also is the disunifying factor that would have had to have been intrinsic to it (to produce the transition from a unified field to a GTR field).

2) **Perfect unity could not have existed for an indefinite period.** The unified state could not have existed indefinitely in the past without being affected by the above-mentioned disunifying factor. If the unified state had existed for an indefinite period, *it would have been in a perfectly stable state* (for "existing unchanged for an indefinite period" is the definition of "a perfectly stable state"). But such a perfectly stable state could never have begun a breakdown or transformation process on its own (for its indefinite unchanged existence reveals the absence of an *intrinsic* efficacious principle of change). Therefore, some *extrinsic* agent, that is, some agent outside of the unified field (i.e., outside of the pre-Big-Bang universe) would have had to have initiated the breakdown or transformation of the perfectly stable (perfectly changeless) unified field. This extra-universal causative agent has the characteristics of God, but unfortunately, God acting as a "*deus ex machina*" in order to make up for a seeming omission in His initial planning or creation. If a "*deus ex machina*" is to be avoided, then the pre-Big-Bang unified era cannot have been unaffected by an intrinsic disunifying factor for an indefinite period of time.

3) **Pre-unified era states could not have existed for an indefinite time.** It may be hypothesized that there was an even more simple physical state preceding the unified era (with its quantum cosmological or super-string configuration). It might be further

supposed that this pre-unified state lasted an indefinite amount of time. However, this cannot be the case for the same reason mentioned in (2) above. Even if a pre-unified state of the universe had existed, it would have had to have undergone a transformation from its state of greater physical simplicity to the unified state. This means that the pre-unified state could not have been perfectly stable (i.e., that it changelessly existed in its particular state indefinitely); for this condition would have required an extrinsic "*deus ex machina*" to initiate its transformation to a less simple unified state. This means that the hypothetical pre-unified state would have had to have had a disunifying factor operating within it during a finite span of time.

4) **No perfectly stable states at any period in the pre-Big-Bang universe.** One may hypothesize any number of eras in a pre-Big-Bang universe. However, all such eras and all such periods within all such eras would have to be finite in duration. Otherwise, one would have to hypothesize a perfectly stable state with no *intrinisic* disunifying factor, which conjecture requires an *extrinsic* "*deus ex machina"* to initiate a transition to the GTR-era. Whenever an indefinite period within the pre-Big-Bang universe is postulated, a perfectly stable state is also postulated; and whenever a perfectly stable state is postulated, an intrinsic disunifying factor is precluded; and whenever an intrinsic disunifying factor is precluded, an extrinsic (extra-universal) *deus ex machina* is postulated. If this last conjecture is to be avoided, all indefinite periods within a hypothetical pre-Big-Bang universe would also have to be avoided.

5) **A finite amount of disunification in a pre-Big-Bang era.** It is reasonable to assume that there would have been a finite amount of disunification between the universe's "most unified pre-Big-Bang state" and its post-Big-Bang GTR open inflationary state, because an infinite amount of disunification would seem to result in complete disunity (complete dispersal akin to complete entropy) rather than a highly unified, orderly emerging GTR universe (which marked the initial period after the Big Bang.

6) **Conclusion.** If (a) event asymmetry occurs through proto-time in any changeable condition of the pre-Big Bang universe (e.g., superstring, quantum cosmological, or other), and if (b) there were no periods of indefinite duration in the pre-Big-Bang universe (implying perfectly stable states and extra-universal *deus ex machinas*), and if (c) there was a finite amount of disunification between the universe's most unified, pre-Big-Bang state to its post-Big-Bang, GTR open inflationary state, then it is very likely that any such pre-Big Bang universe would have been finite in duration. This implies an intrinsic temporal limit to the pre-Big-Bang era(s), and further implies a causative force transcending space-time asymmetry.

Even though the above reasoning process contains ontological analyses (such as the assumption of event asymmetry through proto-time and the unlikelihood of an extra-universal *deus ex machinas* which begs the question of the existence of God anyway) it is not devoid of physical evidence and physical reasoning. If there really was a pre-Big-Bang unified state within our universe, then that universe would have to have undergone a radical transition to a GTR, open inflationary state, which transition implies both changeability and a finite amount of disunification. Though this transition cannot be considered direct physical evidence of an intrinsic temporal boundary to a hypothetical pre-Big-Bang universe, it does, with the help of two ontological analyses, *imply* such an intrinsic temporal boundary. Though this approach will never be completely satisfactory to a physicist, it does present a probative clue to the probable conclusion of future physical investigations. Unfortunately, the current lack of physical evidence does not allow us greater certitude.

If the above analysis is correct, and there really was a pre-Big-Bang unified era, then the following five conditions would have likely been intrinsic to it:

1) A pre-Big-Bang era (and therefore the universe itself) would have been finite in duration, implying a creation event transcending universal space-time asymmetry.

2) That creation would have resulted in a highly unified field of great physical simplicity, having a highly unusual form of gravity and time (possibly expressible through superstring models, quantum cosmological models, combinations of models, or other models of physical simplicity).

3) Given the changeability of this highly unified, very simple state (implied by its transformation into a radically different GTR, open inflationary state), it is quite likely that it was subject to proto-time (as defined above in II.B) and event asymmetry.

4) It is very likely that such a pre-Big-Bang, highly unified field had a "principle of disunification" *intrinsic* to it.

5) This *principle* of disunification caused a finite *process* of disunification. Since this finite process could not have had periods of infinite duration (without implying perfect stability and extra-universal *deus ex machinas*), the process (and therefore, the pre-Big-Bang era) would seem to have been finite in duration.

Conclusion to the Paper

Two ideas should be borne in mind as we proceed to draw conclusions from the above physical evidence. First, metaphysical conclusions cannot be *deduced* from the evidence of physics unless *all* natural processes are *completely* known. If all physical processes are completely known, then the inherent limits of physical causation would also be known, and if these completely known physical processes could not explain the existence of time and the universe, then a metaphysical cause (such as a causative force transcending universal space-time asymmetry) could be legitimately deduced.

However, the current state of physical knowledge is incomplete (as is amply shown in the speculations about quantum cosmology, string theory, and regional inflations). Therefore, we are left with *adducing* (instead of deducing) metaphysical causes of our universe. Adduction brings out as much evidence as possible in both the physical and ontological domains to substantiate reasonable and responsible beliefs. Such conclusions do not follow *necessarily* from their premises, but they are substantiated (and therefore not arbitrary). One cannot arbitrarily deny them unless new evidence is uncovered which mitigates previous evidence or previous models based on that evidence.

Secondly, Hilbert's proscription does constitute a deductive process demonstrating the inherently contradictory nature (and therefore the impossibility) of infinite past time. As such, it stands on its own. However, it is interesting to note that current astrophysics (in combination with two ontological analyses) points *adductively* to an intrinsic temporal limit to universal past time. This forms a complementarity between adductive and deductive (physical and ontological) evidence which has two important effects:

1) mutual corroboration (the ontological corroborating the physical, and the physical corroborating the ontological), and
2) complementarity of information, that is, the deduced, intrinsic limit of universal time complementing the adduced, unfolding process from the intrinsic limit to the present moment; and vice versa.

Bearing these two ideas in mind, we may now draw a fourfold conclusion about the finitude of past-time in the universe (without making recourse to the Hilbertian proscription). Why a fourfold conclusion? Because each conclusion is based upon a different *allowable* interpretation of current evidence from physics. It is important to note here that *each* of these four allowable conclusions adductively substantiates the finitude of universal past time (universal space-time asymmetry). Each of these conclusions has been explained above, and so they will only be reiterated here with references to the appropriate sections in which they are explained.

> **Conclusion (1): Assuming classical Big Bang cosmology alone.** This conclusion, though unlikely, given Linde's and others' evidence for an inflationary era, limits the universe to the classical Big Bang universe (not having a pre-Big-Bang era, and therefore being approximately 13.7 billion years old). If this is true, then classical techniques adduced by Gott, Gunn, Schramm, Tinsley, Sandage, and Tammann show probabilistically that the universe is solely expanding and is 13.7 billion years old. Furthermore, the third condition for a Hawking-Penrose singularity would again become operative (in the absence of vacuum energy predicted by the contemporary Big Bang model) indicating that the universe very likely began at such a singularity constituting a definitive, intrinsic temporal limit of the universe, further indicating a creative force transcending space-time asymmetry (see above, Section I.A and B).
>
> **Conclusion (2): Assuming contemporary Big Bang cosmology, but not multiple inflationary regions or a pre-Big-Bang unified era.** This conclusion is more likely than the first, and at least as likely as the third and fourth conclusions (below). If sufficient vacuum energy exists in the universe to inflate it in the manner described by Linde and Guth, then a universal collapse could not have occurred. The universe would be solely expanding, implying an intrinsic temporal limit approximately 13.7 billion years ago, and further implying the need for a creative force transcending space-time asymmetry (see above, Section II.A).
>
> **Conclusion (3): Assuming contemporary Big Bang cosmology and multiple inflationary regions, but not a pre-Big-Bang unified era.** This conclusion is more speculative than the second because we have no evidence of other universal regions with their own inflationary conditions. If such regions do exist, it will be difficult to find evidence of them because of the likelihood of their initiation at singularities. As Alan Guth has noted, we have not been able to generate a model of inflationary space-time

which does not begin with a singularity (multiple regions and "inflation into an eternal future" notwithstanding). Hence, according to Guth:

> There is even more uncertainty about what happened before inflation, and how inflation began. .... Most likely, however, inflation can be eternal only into the future, but still must have a beginning.[74]

If there is not a pre-inflationary era of the universe, the singularity marking the beginning of inflation would seem to be the beginning of the universe itself, which further implies the need for a creative force transcending space-time asymmetry (see Section II.A, above).

Conclusion (4): Assuming contemporary Big-Bang cosmology, and a pre-Big-Bang unified era – prior to a single or multiple inflationary period(s). This assumption is also speculative because we currently have no remnant of a universal era prior to the Big Bang. However, if there were a pre-Big-Bang era (describable by string theory, quantum cosmology, or some other model of physical simplicity), then the following physical-ontological conclusions would likely obtain: given that (a) event asymmetry occurs through proto-time in any changeable condition of the pre-Big-Bang universe (e.g., superstring, quantum cosmological, or other – see above, Section II.B and C), and given that (b) there were no periods of indefinite duration in the pre-Big-Bang universe (implying perfectly stable states and extra-universal *deus ex machinas* – see above, Section II.D), and given that (c) there was a finite amount of disunification between the universe's most unified, pre-Big-Bang state and its post-Big-Bang, GTR open inflationary state, then it is very likely that any such pre-Big-Bang universe would have been finite in duration. This implies an intrinsic temporal limit to the pre-Big-Bang era(s), and further implies a causative force transcending space-time asymmetry.

These four conclusions represent current interpretations about the Big Bang, regional inflation, and pre-Big-Bang scenarios. Some are more speculative than others, but all adductively indicate an intrinsic temporal limit to the universe, which implies a creative force transcending space-time asymmetry.

The above physical evidence points beyond the creation event to the mentative qualities of the "creative force transcending space-time asymmetry." As noted above, Paul Davies believes that:

> If the initial state were chosen at random, it seems exceedingly probable that the big bang would have coughed out black holes rather than dispersed gases. The present arrangement of matter and energy, with matter spread thinly at relatively low density, in the form of stars and gas clouds would, apparently, only result from a very special choice of initial conditions. Roger Penrose has computed the odds against the observed universe appearing by accident, given that a black-hole cosmos is so much more likely on *a priori* grounds. He estimates a figure of $10^{10^{30}}$ to one.[75]

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[74] Guth 2001, p.1.

[75] Davies 1983, p. 178. See also, Penrose 1979.

These odds are beyond astronomical, and they are relatively unaltered by inflationary theory and other contemporary astrophysical developments. One may want to say that the cosmological constant (giving rise to inflation) in its relation to other fundamental constants explains why the universe avoided the far more probable catastrophic black hole scenarios predicted by Penrose. However, it does not explain why the value of the cosmological constant fits so "coincidentally" with other fundamental constants to avoid such catastrophic scenarios. In light of this, Penrose's and Davies' conclusion about a "very special choice of initial conditions" is as valid today as it was in 1979. The probative value of this reasoning opens the possibility of significant mentative capacity within the "creative force transcending space-time asymmetry."

This idea is further enhanced by the contemporary Big Bang model. If one looks at the general propensity of the universe from the time of the Big Bang, one cannot help but conclude to the general, irreversible tendency toward greater disparity and dispersion. This is manifest not only in universal entropy, but also in the inflationary conditions which dominated the very early universe and may be effective even now (after a redshift of .5). This same propensity would be further verified if there had been a pre-Big-Bang unified era, for the breakdown of the unified field into a GTR field adds one more instance of radical disunification to the ones known to have occurred in the post-Big-Bang universe (i.e., inflation, the breakdown of the universal plasma into particles, the continuous expansion of those particles, etc.).

Yet, in the midst of this general universal tendency toward disunification (disparity and dispersion), the universal constants have subtle interrelationships which allow for the unfolding of systemic instances of greater unification (i.e., in galactic clusters and the eventual emergence of complex schemes of recurrence in carbon bonding, cellular metabolism, and other manifestations of genetic, metabolic, sensate, and conscious activity). One might want to be impressed by the counter-disunifying tendency written into the universe's initial set of conditions which were to become manifest 13 billion years later. The subtlety, intricacy, and seeming "long term planning" which imperceptibly weaves itself into the vastly dominant tendency toward disunity, disparity, and dispersion, gives one pause to recall the words of Arno Penzias:

> Astronomy leads us to a unique event, a universe which was created out of nothing, and delicately balanced to provide exactly the conditions required to support life. In the absence of an absurdly-improbable accident, the observations of modern science seem to suggest an underlying, one might say, supernatural plan.[76]

Though contemporary Big Bang cosmology requires more varied, complex, and even ontological analysis to establish the finitude of past time, it adds a depth, breadth, complexity, beauty, and probity to Penrose's and Penzias' contention about an "underlying supernatural plan." One might derive from this a sense, a kind of probative intuition, about a remarkably deep and comprehensive Intelligence and Beauty.

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[76] Brock 1992 cited in Bradley 1998, p. 40.

REFERENCES

Aristotle. 1941. *The Basic Works of Aristotle*. Ed. by Richard McKeon. (New York: Random House).

----. 1980. *Aristotle's Physics*. Trans. by Hippocrates G. Apostle. (Grinnell, IA: The Peripatetic Press).

----. 1984. *The Complete Works of Aristotle, Vol. 2*. Ed. by Jonathan Barnes. *Metaphysics* trans. by W.D. Ross. (Princeton, NJ: Princeton University Press).

----. 1991. *Aristotle: Selected Works*, 3rd Edition. Trans. by Hippocrates G. Apostle and Lloyd P. Gerson. (Grinnell, IA: The Peripatetic Press).

Aspect, Alain, Dalibard, J, and Roger, G. 1982. *Physical Review Letters*, Vol. 39, pp. 1804ff.

Augustine, St. 1991. *Confessions*. Trans. by Henry Chadwick. (New York: Oxford University Press).

Bradley, Walter L. 1998. "Designed or Designoid?" *Mere Creation: Science, Faith & Intelligent Design*. Ed. by William A. Dembski. (Downers Grove, IL: InterVarsity Press).

Breuer, R. 1991. *The Anthropic Principle: Man as the Focal Point of Nature*. (Boston: Birkhauser).

Brock, D.L. 1992. *Our Universe: Accident or Design?* (Wits, South Africa: Star Watch).

Buchbinder, I.L. 1998. *Ideas and Methods of Supersymmetry and Supergravity, or, A Walk through Superspace*. (Philadelphia, PA: Institute of Physics Pub.).

Callender, Craig and Huggett, Nick, eds. 2001. *Physics Meets Philosophy at the Planck Scale: Contemporary Theories in Quantum Gravity*. (Cambridge: Cambridge University Press).

Cantor, Georg. 1915. *Contributions to the Founding of the Theory of Transfinite Numbers*. Trans. and intro. by Philip E. B. Jourdain. (New York: Dover).

Carter, Brandon. 1974. *Confrontation of Cosmological Theories with Observational Data: Symposiu*m. Ed. by M.S. Longair. (Boston: D. Reidel Publishing Co).

Collins, James. 1959. *God in Modern Philosophy*. (Chicago, IL: Henry Regnery Company).

Coreth, Emerich. 1968. *Metaphysics*. Trans. by Joseph Donceel. (New York: Herder and Herder).

Craig, William Lane 1979. *The Existence of God and the Beginning of the Universe.* (San Bernadino, CA: Here's Life Publishers, Inc.)

----. 1993(a) "The Finitude of the Past and the Existence of God." *Theism, Atheism, and Big Bang Cosmology*. (New York: Clarendon Press), pp. 3-76.

----. 1993(b). "The Caused Beginning of the Universe." *Theism, Atheism, and Big Bang Cosmology*. (New York: Clarendon Press), pp. 141-60.

----. 1993(c). " 'What Place, then, for a Creator?': Hawking on God and Creation." In *Theism, Atheism, and Big Bang Cosmology*. (New York: Clarendon Press), pp. 279-300.

Craig, William Lane and Smith, Quentin. 1993. *Theism, Atheism, and Big Bang Cosmology* (New York: Oxford University Press).

Davies, Paul. 1977. *Space and Time in the Modern Universe*. (New York: Cambridge University Press).

----. 1978. *The Runaway Universe*. (New York: Penguin Books).

----. 1982. *The Accidental Universe*. (New York: Cambridge University Press).

----. 1983. *God and the New Physics*. (New York: Simon and Schuster).

---- and Brown, J.R. 1986. *The Ghost in the Atom*. (New York: Cambridge University Press).

---- and Brown, Julian. 1988. *Superstrings: A Theory of Everything?* (Cambridge: Cambridge University Press).

Davis, P. and Hersh, R. 1981. *The Mathematical Experience*. (Boston: Houghton Mifflin).

Eddington, Sir Arthur. 1928. *The Nature of the Physical World*. (Cambridge: Cambridge University Press).

Einstein, Albert. 1945. *The Meaning of Relativity*. (Princeton, N.J.: Princeton University Press).

----. 1956. *Lettres a Maurice Solovine*. (Paris: Gauthier-Villars).

----. 1961. *Relativity: The Special and the General Theory*. Trans. by Robert W. Lawson. (New York: Crown Publishers, Inc.).

----. 1998. *The Collected Papers of Albert Einstein*. Trans. by Anna Beck; Peter Havas, consultant. (Princeton, N.J.: Princeton University Press).

Feynman, Richard. 1967. *The Character of Physical Law*. (Cambridge: MIT Press).

Fraenkel, Abraham Adolf; Bar-Hillel, Yehoshua; and Levy, Azriel. 1973. *Abstract Set Theory*. (Amsterdam: North-Holland Publishing Co.).

Gamow, George. 1946. *One, Two, Three,…Infinity*. (London: Macmillan).

Gibbons, G.W. and Hawking, S.W. 1993. *Euclidean Quantum Gravity*. (River Edge, NJ: World Scientific).

Gingerich, Owen. 2000. "Do the Heavens Declare." In *The Book of the Cosmos*. Ed by Dennis Richard Danielson. (Cambridge, MA: Perseus Publishing).

Gott III, J. Richard, Gunn, James E., Schramm, David N. and Tinsley, Beatrice M. 1974. "An Unbound Universe?" *Astrophysical Journal* 194, pp. 543-53.

Greene, Brian. 2000. *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*. (New York: Vintage Books).

Gribbin, John. 1984. *In the Search for Schroedinger's Cat*. (New York: Bantam Books).

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

----.1997. *The Inflationary Universe*. (New York: Jonathan Cape).

Hawking, Stephen. 1980. "Theoretical Advances in General Relativity." In H. Woolf (ed.), *Some Strangeness in the Proportion*. (Reading, MA: Addison-Wesley).

----. 1988. *A Brief History of Time: From the Big Bang to Black Holes*. (New York: Bantam Books).

----. 1993. *Black Holes and Baby Universes, and Other Essays*. (New York: Bantam Books).

Herbert, Nick. 1985. *Quantum Reality: Beyond the New Physics*. (New York: Anchor Books).

Herdeiro, Carlos. 1996. "M-Theory, the Theory Formally Known as Strings," in Cambridge Relativity and Cosmology website. Ed. by Paul Shellard. (Cambridge: University of Cambridge).

Hertog, Thomas. 1996. "Quantum Cosmology." In Cambridge Relativity and Cosmology website. Ed. by Paul Shellard. (Cambridge: University of Cambridge).

Hilbert, David. 1964. "On the Infinite." *Philosophy of Mathematics*, ed. by Paul Benacerraf and Hilary Putnam. (Englewood Cliffs, N.J.: Prentice-Hall), pp. 134-151.

Hoyle, Fred. 1951. *The Nature of the Universe*. (New York: Harper).

----. 1981. *Engineering and Science*. (Pasadena, CA: California Institute of Technology, November).

----. 1983. *The Intelligent Universe*. (New York: Holt, Rinehart and Winston).

---- and Fowler, William A. 1973. "On the Origin of Deuterium." *Nature* 241, pp. 384-6.

---- and Wickramasinghe, C. 1981. *Evolution from Space*. (London: J.M. Dent and Sons).

Hubble, Edwin. 1929. "A Relation between Distance and Radial Velocity among Extra-galactic Nebulae." *Proceedings of the National Academy of Sciences* 15, pp. 168-73.

Jastrow, Robert. 1977. *Astronomy Fundamentals and Frontiers*. (New York: Wiley Publishers).

----. 1978. *God and the Astronomers*. (New York: Warner Books).

Kauffman, Stuart A. 1993. *Origins of Order: Self-organization and Selection in Evolution*. (New York: Oxford University Press).

----. 1995. *At Home in the Universe: The Search for Laws of Self-organization and Complexity*. (New York: Oxford University Press.

Kuhnen, K. 1977. "Combinatorics." *Handbook of Mathematical Logic*. Ed. by Jon Barwise. (Amsterdam: North Holland Press), pp. 371-401.

Leibniz. 1956. *Philosophical Papers and Letters*, vol. 2. Ed. and trans. by R. Latta. (Oxford: Oxford University Press).

Liddle, Andrew R. 2000. *Cosmological Inflation and Large-Scale Structure*. (Cambridge: Cambridge University Press).

Linde, A. D. 1986(a). "Eternal Chaotic Inflation." Mod.Phys.Lett., A1, 81.

----. 1986(b). "Eternally Existing Self-Reproducing Chaotic Inflationary Universe." Phys.Lett, B175, 395.

----. 1994. "The Self-Reproducing Inflationary Universe." *Scientific American*. November, pp. 48-56.

----. 1998. "The Self-Reproducing Inflationary Universe." *Scientific American*. Special issue on cosmology, Spring, pp. 98-104.

Lonergan, Bernard. 1992. *Insight: A Study of Human Understanding*. In *Collected Works of Bernard Lonergan* 3, ed. by Frederick E. Crowe and Robert M. Doran. (Toronto: University of Toronto Press).

Moss, Ian G. 1996. *Quantum Theory, Black Holes, and Inflation*. (New York: Wiley).

Newton, Sir Isaac. 1756. *Four Letters from Sir Isaac Newton to Doctor Bentley, Containing Some Arguments in Proof of a Deity*. (London: R. and J. Dodsley).

----. 1999. *Isaac Newton's Observations on the Prophecies of Daniel and the Apocalypse of St. John*. Ed. by S.J. Barnett. (Lewiston: E. Mellen Press).

Pasachoff, J.M. and Fowler, William A. 1974. "Deuterium in the Universe." *Scientific American*. May.

Penrose, Roger. 1965. "Gravitational Collapse and Space-Time Singularities." *Physical Review Letters* 14, pp. 57-9.

----. 1974. "Singularities in Cosmology." In M.S. Longair (ed.), *Confrontation of Cosmological Theories with Observational Data*. (Boston: D. Reidel).

----. 1979. "Singularities and Time-asymmetry." In *General Relativity: An Einstein Centenary Survey*, ed. by Stephen Hawking and W. Israel. (Cambridge: Cambridge University Press).

Penzias, Arno A. and Wilson, Robert W. 1965. "A Measurement of Excess Antenna Temperature at 4080 Mc/s." *Astrophysical Journal* 142, pp. 419-21.

Polkinghorne, John P. 1996. *The Faith of a Physicist: Reflections of a Bottom-Up Thinker*. (Minneapolis, MN: Fortress).

----. 1998. *Belief in God in an Age of Science*. (New Haven, CT: Yale University Press).

Prigogine, Ilya. 1980. *From Being to Becoming*. (New York: Freeman).

Robinson, Abraham. 1966. *Non-Standard Analysis*. (Amsterdam: North Holland Press).

----. 1969. "The Metaphysics of the Calculus." *The Philosophy of Mathematics: Oxford Readings in Philosophy*. Ed. by Jaakko Hintikka. (London: Oxford University Press).

Rotman, B. and Kneebone, G.T. 1966. *The Theory of Sets and Transfinite Numbers* (London: Oldbourne).

Sandage, Allan R. 1970. "Cosmology: A Search for Two Numbers." *Physics Today*. February.

----. and G.A. Tammann. "Steps Toward the Hubble Constant." *Astrophysical Journal* in multiple parts – i: 190 (1974), pp. 525-38; ii: 191 (1974), pp. 603-21; iii: 194 (1974), pp. 223-43; iv: 194 (1974), pp. 559-68; v: 196 (1975), pp. 313-28; vi: 197 (1975), pp. 265-80.

Silk, Joseph. 1980. *The Big Bang*. (San Francisco: W.H. Freeman).

Smith, Quentin. 1993(a). "The Uncaused Beginning of the Universe." In *Theism, Atheism, and Big Bang Cosmology*. (New York: Clarendon Press), pp. 108-139.

----. 1993(b) "Atheism, Theism, and Big Bang Cosmology." In *Theism, Atheism, and Big Bang Cosmology*. (New York: Clarendon Press), pp. 195-217.

Spitzer, Robert J. 1989. *A Study of the Nature of Objectively Real Time.* (Ann Arbor, MI: U.M.I.)

----. 2000(a). "Definitions of Real Time and Ultimate Reality." *Ultimate Reality and Meaning: Interdisciplinary Studies in the Philosophy of Understanding* 23:3, pp. 260-267.

----. 2001(a). "Proofs for the Existence of God, Part I: A Metaphysical Argument." *International Philosophical Quarterly* 41:2, June, pp. 161-181.

----. 2001(b). "Proofs for the Existence of God, Part II." *International Philosophical Quarterly*. 41:3, September, pp. 305-331.

----. 2003. "Indications of Creation in Contemporary Big Bang Cosmology." *Philosophy in Science* Vol. 10. (Tucson, Pachart Publishing).

Steinhardt, P. J. 1983. "In The Very Early Universe." *Proceedings of the Nuffield Workshop, Cambridge*, 21 June – 9 July, 1982, ed. G.W. Gibbons, S.W. Hawking, and S.T.C. Siklos (Cambridge: Cambridge University Press), 251.

Steinmetz, Charles Proteus. 1967. *Four Lectures on Relativity and Space*. (New York: Dover Publications, Inc.).

Tryon, E.P. 1973. "Is the Universe a Vacuum Fluctuation?" *Nature* 246.

Vilenkin, A. 1982. "Creation of Universes from Nothing." *Physical Letters* 117B.

----. 1983. "Birth of Inflationary Universes." Phys.Rev., D27, 2848.

von Neumann, John. 1955. *Mathematical Foundations of Quantum Mechanics*. Trans. by Robert T. Beyer. (Princeton, N.J.: Princeton University Press).

Whitrow, G.J. 1954-55. "The Age of the Universe." *British Journal for the Philosophy of Science*, 5, pp. 215-225.

----. 1968. "Time and the Universe." *The Voices of Time*. Ed. by J.T. Fraser. (London: Penguin Press).

----. 1970. "Time and Cosmical Physics." *Studium Generale*, 23, pp. 224-233.

----. 1978. "On the Impossibility of Infinite Past Time." *British Journal for the Philosophy of Science*, pp. 39-45.

Zippin, Leo. 1962. *Uses of Infinity*. (Washington D.C.: Mathematical Association of America).