Evidence for God from Physics and Philosophy:

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Introduction

The natural sciences (and philosophical reflection upon them) have been an integral part of the Catholic intellectual tradition since the time of the Copernican revolution. Indeed, Catholic priests and clerics played a central role in the development of natural science, for example, Nicolaus Copernicus (1473-1543, the originator of the heliocentric universe and its mathematical justification -- 1540) was a Catholic cleric.[1] Nicolas Steno (1638 – 1686, a Catholic Danish Bishop) is acknowledged to be one of the founders of modern stratigraphy and geology.[2] The Augustinian monk and abbot, Gregor Mendel (1822-1884), is acknowledged to be the founder of modern genetics.[3] As will be discussed below, Monsignor Georges Lemaître (a Belgian priest and colleague of Albert Einstein) is acknowledged to be the founder of contemporary cosmology (the Big Bang theory in 1927).[4] There are many other Catholic clerics who were integrally involved in the foundation and development of the natural sciences.[5]

Some have contended that the Catholic Church manifested an "antiscientific attitude" during the controversy with Galileo, but the controversy was not about the veracity of scientific method or its seeming heliocentric conclusion. The Jesuits of the Roman College helped Galileo to confirm mathematically his version of the heliocentric theory, and considered him to be an esteemed colleague and friend. The relationship broke down only when Galileo disobeyed the Pope about announcing the heliocentric universe as *fact* (before adequate astronomical observations could be made to confirm the theory through a technique called "stellar parallax").[6] He exacerbated the strained relationship when he called the Pope and the Jesuits "fools" because of their reservation. The Catholic Church has never been "anti-science," but rather creatively instrumental in its development, making science to be an integral part of its intellectual tradition.

An additional point should be made at the outset – contemporary physics cannot avoid philosophical analysis because its conclusions have pushed into the domain of metaphysics. In Section I, we will discuss how the conclusions of contemporary cosmology need clarification from philosophy to show the proper limits and horizons of its method. In Section V, we will see how conclusions of contemporary cosmology inevitably lead into the domain of metaphysics.

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[1] Copernicus was a devout Catholic who took minor orders as a Catholic cleric and was a canon lawyer within the Catholic Church, but he did not proceed to ordination as a priest. See Armitage 1990.
[2] See Hansen 2009.
[3] See Henig 2000.
[4] Though Fr. Lemaître was too humble to assert the primacy of his discovery over that of Edwin Hubble (two years later), Lemaître is widely acknowledged today to be the true founder of the Big Bang theory – one of the most rigorously established theories in contemporary physics. The theory has undergone many modifications since the time of Fr. Lemaître (1927), but the general theory of the expanding universe remains the same. See Livio 2011 and Plotner 2011.
[5] See "List of Roman Catholic Cleric Scientists." (http://en.wikipedia.org/wiki/List_of_Roman_Catholic_cleric%E2%80%93scientists).
[6] The stellar parallax technique is essential to confirming the earth's movement around the sun, but astronomical observations of distant stars were not accurate enough to confirm the earth's movement relative to the sun until over 200 years after Galileo – in 1839 by Friedrich Bessel. The Pope and the Jesuits were justified in asking Galileo not to claim his theory as fact until this critical astronomical observation had been made. Unfortunately, he chose not to do so, and the controversy (and breakdown of a long standing collegial relationship) began. See Wallace 1984 and DeMarco 1986 pp 23-51 and 53-59.

This analysis should help physicists to avoid some of the unbelievably naive metaphysical and philosophical claims made in recent years. Stephen Hawking – in his recent book *The Grand Design*, for example, has joined the ranks of this group by asserting:

> What is the nature of reality? Where did all this come from? Did the universe need a creator? ... Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge.[7]

He further asserts in the same book another more remarkable claim -- that spontaneous creation can occur from nothing, because of the law of gravitation and M Theory.[8] These assertions are filled with so many logical, methodological, and metaphysical errors, that it will take the majority of Sections I, V, and VI to respond to them.

I.
Physical and Metaphysical Method: Can Science Indicate Creation?

We should begin by clarifying what science can really tell us about a beginning of the universe and supernatural causation. First, unlike philosophy and metaphysics, science cannot *deductively* prove a creation or God. Natural science deals with the physical universe and with the regularities which we call "laws of nature" that are obeyed by the phenomena within that universe. But God is not an object or phenomenon or regularity within the physical universe; so science cannot not say anything about God.

Moreover, science is an empirical and inductive discipline. As such, science cannot be certain that it has considered all possible data relevant to a complete explanation of particular physical phenomena or the universe itself. It must always remain open to new data and discoveries which could alter its explanation of particular phenomena and the universe. This can be seen quite clearly in the movement from the Newtonian view of the universe to the Einsteinian one or from the Ptolemaic view of the solar system (geocentric) to the Copernican one (heliocentric).

So what *can* science tell us? It can identify, aggregate, and synthesize evidence indicating the finitude of past time in the universe (as we currently know it to be and conceive it could be). Science can also identify the exceedingly high improbability of the random occurrence of conditions necessary to sustain life in the universe (as we currently know it to be and conceive it could be).

Though scientific conclusions are subject to change in the light of new data, we should not let this possibility cause us to unnecessarily discount the validity of long-standing, persistent,

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[7] Hawking and Mlodinow, 2010 *The Grand Design (*New York: Bantam) p. 1

[8] "Because there is a law such as gravity, the Universe can and will create itself from nothing…Spontaneous creation is the reason there is something rather than nothing, why the Universe exists, why we exist" (Hawking and Mlodinow 2010 p 180).

rigorously established theories. If we did this, we might discount the majority of all scientific theories. Thus, it is reasonable and responsible to attribute qualified truth value to such theories until such time as new data requires them to be modified.

The arguments that suggest the finitude of past time, i.e. that time had a beginning, are basically of two types: (a) arguments about the possible geometries of space-time and (b) arguments based on the Second Law of Thermodynamics (entropy). Though the arguments we shall give may conceivably have loopholes, in the sense that cosmological models or scenarios may be found in the future to which these arguments don't apply, their persistence and applicability to a large number of existing cosmological models gives them respectable probative force. Until such time as they are shown to be invalid or inapplicable to empirically verifiable characteristics of our universe, they should be considered as justifying the conclusion that it is at least highly probable that the universe had a beginning.

When we speak of a beginning (a point prior to which there is no physical reality), we stand at the threshold of metaphysics (beyond physics). Even though science cannot be validly used to prove a metaphysical claim (such as, "a Creator or God exists"), it can be used (with the qualifications mentioned above) to maintain as highly probable a limit to physical reality (such as a beginning). This *scientific* evidence for a beginning can be combined with a *metaphysical* premise (such as "from nothing, only nothing comes") to render a *metaphysical* conclusion that there must be *something* beyond physical reality which caused physical reality to exist (i.e. a transcendent cause).

There are other indications of supernatural causation arising out of contemporary cosmology besides the implications of a beginning -- namely the occurrence of several cosmological conditions essential for the development and sustenance of any life form, that seem at least prima facie to be highly improbable. These seemingly highly improbable conditions (which are sometimes called "cosmic coincidences" or "anthropic coincidences") imply an element of supernatural fine-tuning if no satisfactory naturalistic explanation can be found for them.

The existence of a Creator does not rest on scientific cosmological evidence alone. There is sufficient rational grounds to affirm the existence of a Creator without modern science.[9] Nevertheless, the purely philosophical and metaphysical arguments and the arguments based on the findings of modern science complement and corroborate each other. This complementarity and corroboration constitute a network of evidence. John Henry Newman termed such a network of evidence an "informal inference," that is, reaching a conclusion by considering the accumulation of converging independently probable data sets. This allows for possible modification of one or more of the sets without significantly changing the general conclusion (see below Section VII).

Using the foregoing methodological considerations as a foundation, we may now respond to three naturalistic claims that have become widely accepted in popular culture:

1. Science can and has disproved the existence of a Creator.

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[9] See the three proofs in Spitzer 2010 (a), Chapters Three through Five.

2. Science currently knows everything about the universe sufficient to conclude that the universe does not need a Creator.
3. Science can give no evidence for a transcendent Creator.

Let us begin with the first naturalistic claim (science can disprove a Creator). This claim is completely beyond the domain of science, because scientific evidence must be observational (whether it be directly observed, measured, inferred from an experiment, etc.). This observational evidence is limited to our universe (and even to our event horizon within the universe). However, a *transcendent* Creator would have to be beyond the confines of our observational data, and so science cannot *disprove* the existence of a transcendent Creator. An elaboration of the problem will make this clear.

It is much more difficult to disprove something by means of observation than to prove it. For example, if I want to prove the existence of an alien, I need to see only one, however, if I wish to disprove the existence of aliens by observational method, I would have to observe everything that there was to observe in the universe, know with certainty that all realities within the universe come within my purview and observational powers, and then notice that it is not there. Thus, *disproving* by means of observation requires a comprehensive search and infallible certitude that all realities can be observed by the observer (which certainly cannot be known through observation!).

The problem becomes even worse when we are speaking about a reality outside of the observable universe (such as a transcendent Creator, or God). This would entail observing everything there was to observe *outside* the universe, knowing that all realities outside the universe were in fact observable, and noticing that it is not there. This is evidently an impossible task – enough said.

Let us turn to the second naturalistic claim – namely that science now knows enough about the universe to know with certainty that the universe does not need a Creator.[10] This contention cannot be the case today or at any other time in the future, because science is an *inductive* discipline. This means that science proceeds from specific observational data to theories that coherently unify this data. Sometimes scientists are able to formulate "rigorously established" theories which are corroborated by multiple different data sets and a convergence of the mathematics intrinsic to those data sets (such as the Big Bang theory). Though rigorously established theories should be considered to indicate truth, they can never be known with infallible certitude, because scientists can *never* know what they do not know until they have discovered it. Theories are not theorems (proofs). They are only coherent unifications of *currently available* data (observations). Thus, scientists can never know whether their theories are completely explanatory (i.e. know that there are no data in the universe unaccounted for). Inasmuch as the completeness of a theory cannot be known by observational evidence, it cannot be known by science, and for this reason science must remain open to further discoveries –

[10] See the discussion on the Larry King Show between Stephen Hawking, Leonard Mlodinow, Deepak Chopra, and Fr. Robert Spitzer (http://www.youtube.com/watch?v=9AdKEHzmqxA). This is Hawking's and Mlodinow's contention.

always.[11] Therefore, science can never know with certainty that the universe does not need a Creator, because it cannot know with certainty that it has accounted for all data in the universe affecting the answer to this question. Furthermore, this claim conflicts directly with the evidence for a creation of the universe discussed below.

We proceed finally to the third naturalistic claim – namely, that science can give no evidence for a transcendent reality (such as a Creator or God). At first it might seem that if science *cannot* give evidence against a Creator, then it should not be able to give evidence for a Creator. However, recall from above that it is much easier to prove something with observational evidence than to disprove it, because disproving requires observing everything that is real, and noticing that a hypothetical entity is not there. Accomplishing this task for an entity outside the universe (outside of our observational horizon) is impossible. However, if one could show that the universe (and even physical reality itself) cannot explain its own existence, then it would be possible to give evidence for a reality beyond the universe. So is there any evidence *within* the universe that shows that the universe cannot explain itself? As a matter of fact there is – a finite limit to past time or what is commonly called "a beginning." As noted above, if science could show through observational evidence that the universe (and even physical reality itself) must have a beginning, then this datum could be combined with a metaphysical premise (that physical reality was absolutely nothing before the beginning) to show that the universe could not have moved itself from nothing to something before the beginning. This would require a transcendent Creator to move physical reality from nothing to something at the beginning.

Well then, can science give evidence for a beginning of the universe, the beginning of a multiverse, and even the beginning of physical reality itself? We now proceed to Sections II through IV for that answer.

II.
Fr. Georges Lemaître, the Big Bang Theory, and the Modern Universe

As noted in the introduction, Monsignor Georges Lemaître, a Catholic priest, noted cosmologist, and colleague of Einstein's, discovered the Big Bang theory in 1927.[12] As will be explained below (Section III, Step (1)), Lemaitre ingeniously solved the problem of how the recessional velocities of distant galaxies could be greater than those of nearer galaxies. The idea was really quite radical – so much so that Einstein, though impressed with Lemaitre's mathematics, rejected it at first. Lemaitre theorized that galaxies were not moving in fixed Euclidean space, but rather that the space between the galaxies was stretching and growing, which might be analogized by a balloon being inflated. Think for a moment about a balloon with many dots on it, and liken the elastic of the balloon to the spatial manifold (spatial field) and the dots on the balloon to galaxies. Now circle one of the dots on the balloon, and call it the Milky Way (our galaxy), and

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[11] The idea that M Theory is perfectly explanatory is doubly fallacious. Though M Theory *can* show how an eleven dimensional vibrating string configuration could give rise to all the kinds and spins of particles, no scientist can know that M Theory exhausts the whole of physical reality (for the reasons mentioned above). There is a second problem with this contention – namely, that we currently do not have any evidence for string theory (or M Theory), and it looks as if these theories may be inapplicable to some aspects of the observable universe. See Dine 2004; see Gordon 2010.

[12] Mario Livio 2011.

begin blowing up the balloon. Notice that every time you exhale into the balloon and stretch the elastic more, the farther dots from us expand more than the nearer dots. Why did the farther dots move farther away from us than the nearer dots? Because there was more space – more balloon -- between them and us (than between the nearer galaxies and us). So, Lemaître reasoned that the more space there was to stretch and grow, the more stretching and growing would occur, and the more stretching and growing that occurred, the greater the recessional velocity would be (distance a galaxy moves away from us per unit time).

Lemaitre knew that Einstein's General Theory of Relativity allowed not only for the spatial field to have a variable geometry (such as a curved geometrical configuration surrounding dense fields of mass-energy), but also for space to stretch and grow like the expansion of a balloon. He showed with great mathematical precision that the expansion of the universe as a whole was the best explanation of the recessional velocities of distant galaxies, but his conclusion was so radical that Einstein and others found it difficult to accept. Furthermore, it had the consequence that the universe may have had a beginning (a creation), which was a true departure from previous scientific assumptions. Why does Lemaitre's theory have such a consequence? If the universe truly is expanding as a whole (irrespective of whether it expands uniformly like a balloon or not) it must have been less expanded in the past, and even less expanded as we go further back into the past. Today there is only a finite distance between galaxies, and so we know that the universe could not have been expanding forever in the past. All of the points must have been arbitrarily close to one another at some time *in the finite past.* If the Big Bang[13] marks the initial expansion of the universe, then it could be the *beginning* of the universe. We have very good evidence today that this event occurred about 13.8 billion years ago (plus or minus 100,000,000 years).

Nothing like this had ever been considered in the natural sciences before Fr. Lemaitre's theory. Aristotle and St. Thomas Aquinas believed that the evidence of reason could not establish a beginning of time, and so natural philosophy would have to assume the eternity of the universe. St. Thomas thought that the finitude of time in the universe could only be known through the revelation of God (requiring faith). Sir Isaac Newton made the same assumption, and so did his followers, right up to the time of Fr. Lemaitre. Though Lemaitre did not prove that the Big Bang was the beginning of the universe, his theory implied that it could be, and this radically changed the intellectual landscape (and horizon) of the natural sciences. Lemaitre put it this way:

> We can compare space-time to an open, conic cup.
> The bottom of the cup is the origin of atomic disintegration:
> it is the first instant at the bottom of space-time, the now
> which has no yesterday because, yesterday, there was no space.[14]

Lemaitre's theory was first confirmed two years later by Edwin Hubble's survey of the heavens (at Mt. Wilson Observatory), in which he showed through a well-known technique called red-shifting that more distant galaxies are indeed moving away from our galaxy faster than those

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[13] Fr. Georges Lemaitre did not use the term "Big Bang," but rather, "the Theory of the Primeval Atom." Sir Fred Hoyle (when he was in his atheistic phase) sneeringly dubbed Lemaitre's theory "the Big Bang" to trivialize and insult it.

[14] Lemaitre 1943 p 133.

nearer to us. Hubble invited Einstein to Mt. Wilson to check the results which apparently caused him to change his mind. When Einstein and Lemaitre co-presented at a conference at Mt. Wilson in 1933, Einstein reputedly said "This is the most beautiful and satisfactory explanation of creation to which I have ever listened."[15] Since that time, Lemaitre's theory has been confirmed in a variety of different ways, making it one of the most comprehensive and rigorously established theories in contemporary cosmology.

After Hubble's confirmation through the redshifts detected in his survey of the heavens, Arno Penzias and Robert Wilson made another remarkable confirmation in 1965 through a very different approach. They inadvertently discovered a 2.7 degree Kelvin uniformly distributed radiation throughout the universe which could have occurred only at a very early, cosmic-wide event (the Big Bang and its immediate aftermath).[16] They received the Nobel Prize for this discovery in 1978.

The Big Bang was subsequently confirmed by data from the cosmic background explorer satellites (COBE) #1 and #2,[17] the Wilkinson Microwave and Isotropy Probe (WMAP),[18] and very recently by the Planck satellite.[19] These confirmations verify Fr. Lemaitre's general concept of the Big Bang, and add considerably more data to it – such as quantum gravity, inflationary theory, dark matter, and dark energy (described briefly below).

So what do physicists think happened 13.8 billion years ago? It seems that our universe took a quantum cosmological form in which all four forces (the electromagnetic force, the strong nuclear force, the weak force, and the gravitational force -- in a quantized form) were completely unified, and then exploded. At that moment the space-time manifold came into existence and energy emerged in it (in a fashion explicable by Einstein's General Theory of Relativity). The strong nuclear force separated from the electroweak force, and then the weak force separated from the electromagnetic force, which then moved through a Higgs field slowing it down to produce the rest mass of particles (such as protons and neutrons), making up the visible constituents of the universe. A plasma era ensued, followed by stellar nucleosynthesis and galactic formation, eventually giving rise to planets – and even some very special planets similar to the Earth.[20]

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[15] Topper 2013 p. 175 and also *New York Times* 2005 "Even Einstein Had His Days Off" in Opinion *New York Times* (www.nytimes.com/2005/01/02/opinion/02singh.html).
[16] Penzias and Wilson. 1965 pp 419-421.
[17] NASA Report on the Findings of the COBE Satellites. (http://lambda.gsfc.nasa.gov/product/cobe/).
[18] NASA press conference with NASA Director, Charles Bennett on data from the WMAP Satellite 2008. www.space.com/scienceastronomy/map_discovery_030211.
[19] NASA Press conferences on Planck Satellite 2013 (www.**nasa**.gov/**planck**) **and (**www.**nasa**.gov/mission_pages/**planck**/news/**planck**20130321.html).
[20] The current estimate of such special planets in the Milky Way is approximately 40 billion according to researchers Erik Petigura and Geoffrey Marcy of the University of California, Berkeley, along with Andrew Howard of the University of Hawaii, using data from the Kepler Satellite (designed to detect planets in our galaxy and beyond) see NPR news report, November 2013 "Just How Many Earth-like Planets are Out There?" (www.npr.org/2013/11/05/242991030/galaxy-quest-just-how-many-earth-like-planets-are-out-there). Does life exist on any of these planets? Nobody knows. There is a possibility that some of these planets may be able to sustain life, and therefore may have life, but current investigations have not found any data to support this (such as the Mars Curiosity Rover).

The observable universe appears to have approximately 10^{55} kilograms of visible matter, about five times more dark matter (25% of the universe)[21] and considerably more dark energy (about 70% of the universe).[22] The visible and dark matter is distributed in 10^{22} stars (and accompanying planets) within 10^{11} galaxies. The galaxies maintain their volume because of visible matter, dark matter, and a giant black hole in their centers. However, the space between the galaxies is stretching at an accelerated rate (inflating) because of dark energy. It is highly unlikely that the universe will collapse in the future (in a big crunch followed by a bounce), because it's probable flat geometry and dark energy will cause it to expand indefinitely. Therefore, the universe will reach a point of either a "big freeze" (in which the gases necessary for star formation will be exhausted, and all formed stars will use up their supply of gases) or "heat death" (in which the universe reaches maximum entropy) a finite time in the future (somewhere between 1 trillion and 100 trillion years from now).

This brings us to three central questions: Was the Big Bang the beginning of our universe? Does our universe exhaust the whole of physical reality (or is there some dimension of physical reality beyond our universe)? If physical reality does extend beyond our universe, must it have a beginning?

Quantum gravity[23] and inflation theory[24] allow for the formation of four major speculative theories which might expand our view of physical reality far beyond our observable universe:

1. The *multiverse hypothesis* – inflationary theory allows for the possibility of a giant inflating universe that can produce a multiplicity of bubble universes indefinitely into the future. One such bubble universe would be our own.

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[21] Dark matter does not emit or absorb light or heat, so it is not detectable by traditional methods. It is currently thought to take the form of very fine particles which interact with the space-time manifold in the same way as visible matter (causing an increased curvature of the manifold in proportion to its density). It is what keeps the galaxies of the observable universe from flying apart (in the accelerated fashion of the space between the galaxies).

[22] Dark energy is quite different from dark matter. Instead of interacting with the space-time manifold in a way that causes contraction, it causes repulsion. It seems to have a field-like dimensionality that causes the space-time manifold to stretch and grow at an accelerated rate, causing the phenomenon known as inflation. There is some convincing evidence of inflation from the Planck Satellite and other observations, and the best current explanation for this inflation is dark energy.

[23] Quantum gravity is a hypothetical field of physics that tries to describe the quantum behavior of the force of gravity. The classical description of gravity is explained in Einstein's General Theory of Relativity (through a malleable space-time manifold). Some theories of quantum gravity are used to explain a pre-Big Bang condition (prior to the advent of the space-time manifold described by the General Theory of Relativity). The two most popular theories are string theory and loop quantum gravity. This field of physics may remain quite hypothetical into the future, because its effects can only be observed near the Planck scale, which is far too small to be currently detected.

[24]Inflation theory (first described by Dr. Alan Guth to resolve various problems in the standard Big Bang model) describes the extremely rapid exponential expansion of the early universe by a factor of at least 10^{78} in volume. The inflation epoch seems to have taken place in the first part of the electroweak era (when the universe was only 10^{-36} seconds to 10^{-33} seconds old). Inflation arises out of vacuum energy (dark energy) which has the opposite effect of mass-energy on the space-time manifold. In the General Theory of Relativity, the density of mass-energy causes an increased curvature of the space-time manifold (giving rise to a force of attraction). However, the density of vacuum energy causes the space-time manifold to expand and stretch at an accelerated rate, (causing a repulsive effect).

2. The *bouncing universe hypothesis* – since the time of Albert Einstein, the conventional bouncing universe hypothesis took the general form of a cyclic universe which expanded, and then contracted in a "big crunch," and then bounced and re-expanded repeatedly. The expansion from the Big Bang until today is theorized to be one such cycle – the last one amidst many others.
3. The *pre-Big Bang eternally static hypothesis* – quantum gravity allows for the possibility of a pre-Big Bang era in which the universe was perfectly stable for a long period of time prior to the Big Bang.
4. The *higher dimensional space universe hypothesis* – string theory (particularly M Theory) allows for the possibility of universes to exist in higher dimensional space (consisting of say, eleven dimensions), permitting unusual complex expanding and bouncing universes.

All of these hypotheses extend our view of physical reality beyond our observable universe, which may allow physical reality to exist prior to our 13.8 billion year old history (since the Big Bang) – and even eternally into the past. As noted above, they are all completely hypothetical and lie beyond our current capacity to observe. They may in principle, be unobservable. As will be seen (below in Sections III – V), every one of these scenarios very probably requires a *beginning in the finite past,* and for this reason, brings physics to the threshold of metaphysics.

III.
Space-Time Geometry Proofs and the Beginning of Physical Reality

Lemaitre's discovery of the expansion of space-time in the universe (as a whole) enabled physicists to formulate theorems (proofs) about the necessity of a beginning. All such proofs are based on various physical (observable) data which must all be true in order for the conclusion (about a beginning of the universe) to be true. They take the following general form: "If condition A, condition B, and condition C are true, then there must be a beginning of the universe (or the beginning of a multiverse or the beginning of physical reality itself)."

The first space-time geometry proof (called a singularity theorem) was proposed by Stephen Hawking and Roger Penrose between 1968 and 1970[25] which was based on five conditions. In 1980 Hawking declared "a curvature singularity that will intersect every world line… [makes] general relativity predict a beginning of time."[26] Twenty years after they formulated the proof, Alan Guth proposed inflationary theory which appeared to violate the third condition of the Hawking-Penrose proof ("the mass density and pressure of matter never become negative"). Inflation (presumably caused by dark energy) produces negative pressure (accelerating expansion) which violates the third condition of the proof.

This was only a temporary setback for space-time geometry proofs of a beginning. In 1994, Arvind Borde and Alexander Vilenkin devised a proof for a singularity (and beginning of the universe) accounting for *inflationary* cosmology.[27] However, they found an exception to their proof in 1997 with regard to the weak energy condition. Even though this exception was highly

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[25] Hawking and Penrose 1970. pp 529-548.
[26] Hawking 1980, p.149.
[27] Borde and Vilenkin 1994 pp 3305-3308.

unlikely in our universe, it re-opened the possibility of an eternal universe (in the past).[28] During the same period, Alan Guth tried to show that all known mathematical configurations of inflationary model cosmologies required a beginning.[29] Though Guth's study was comprehensive, it did not constitute a proof of a singularity in all inflationary cosmologies.

In 2003, all three joined together to formulate an elegant proof of a boundary to past time in all cosmologies where the average Hubble expansion is greater than zero. This proof is not dependent on the weak energy condition (which allowed for possible exceptions to the 1994 Borde-Vilenkin proof). They formulated their findings as follows:

> Our argument shows that null and time like geodesics are, in general, past-incomplete [requiring a boundary to past time] in inflationary models, whether or not energy conditions hold, provided only that the averaged expansion condition $H_{av} > 0$ hold along these past-directed geodesics. This is a stronger conclusion than the one arrived at in previous work in that we have shown under reasonable assumptions that almost all causal geodesics, when extended to the past of an arbitrary point, reach the boundary of the inflating region of space-time in a *finite* proper time.[30]

Remarkably, this proof (which is explained in detail below in this Section) has extensive general applicability—that is, to *any universe* with an average Hubble expansion greater than zero. In particular, it applies to the eternal inflation scenario. Vilenkin states it as follows:

> We made no assumptions about the material content of the universe. We did not even assume that gravity is described by Einstein's equations. So, if Einstein's gravity requires some modification, our conclusion will still hold. The only assumption that we made was that the expansion rate of the universe never gets below some nonzero value, no matter how small. This assumption should certainly be satisfied in the inflating false vacuum. The conclusion is that past-eternal inflation without a beginning is impossible.[31]

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[28] Borde and Vilenkin 1997 p 720.

[29] "In my own opinion, it looks like eternally inflating models *necessarily* have a beginning. I believe this for two reasons. The first is the fact that, as hard as physicists have worked to try to construct an alternative, so far all the models that we construct have a beginning; they are eternal into the future, but not into the past. The second reason is that the technical assumption questioned in the 1997 Borde-Vilenkin paper does not seem important enough to me to change the *conclusion."* (Guth 1999) p 13.

[30] Borde, Guth, and Vilenkin 2003 p 3

[31] Vilenkin 2006 p 175

The implications of Vilenkin's statement should not be underestimated, for he is claiming that the proof is valid almost *independently of the physics* of any universe (except for the one condition that the average expansion rate of the universe or multiverse be greater than zero). He is further claiming that such a universe without a beginning is *impossible*.

This proof is virtually universally applicable and very difficult to disprove (because it has only one condition). Its importance merits further explanation (which can be done through logical steps with very little mathematical analysis). The following five steps indicate the logical and empirical validity of the proof.

1. The First Step comes from Fr. Georges Lemaitre in 1923 -- the farther a galaxy is from our galaxy, the greater will be its recessional velocity (its speed going away from the observer). Recall what was said about the universe expanding like a balloon -- if space is stretching (growing like the elastic of our balloon), then the further a galaxy is from us (the observer), the greater its recessional velocity will be. Why? Because galaxies are not simply moving away from each other in fixed space; the space between the galaxies is actually stretching and growing (like the balloon). Thus, the more space there is between my galaxy and another galaxy, the more space there is to stretch and grow, and so we would expect that there would be more growing of space between our galaxy and a far distant galaxy than between our galaxy and a nearer one. This should increase the recessional velocity in proportion to a galaxy's distance from our galaxy. Hubble had a precise equation to calculate this -- $v = H_0D$ (where v is the recessional velocity of a distant galaxy, D is the proper distance of that galaxy from our galaxy, and H is the Hubble constant which transforms proper distance into recessional velocity). Today the Hubble constant is thought to be 69.32 ± 0.80 (km/s)/Mpc – (kilometer per second) per megaparsec.

   We can illustrate this very simply with a rubber band. Take out a rubber band and put it on top of a ruler. Now draw a dot on the rubber band at point zero; another dot at one inch; and yet another dot at two inches. Now, take the rubber band and hold it with your left hand at point zero. With your right hand stretch the rubber band so that the dot that was at two inches is now at four inches. Evidently the dot which was at two inches from origin has expanded another two inches (to the four inch mark). But notice that the dot which was at the one inch mark has only moved to the *two inch mark* (*an expansion of only one inch*). Thus, if space as a whole is growing like a balloon (or like our rubber band), the farther away a galaxy is from our galaxy (at point zero on the ruler), the more it expands per unit time. Since recessional velocity is "expansion per unit time" Lemaitre proved his point – the farther away the galaxy is, the greater its recessional velocity will be – if space between the galaxies is expanding (instead of galaxies moving away from each other in fixed space).

2. The Second Step: We must now learn yet another concept – namely, relative velocity. This term refers to the velocity of a projectile (say, a rocket) approaching a galaxy which is moving away from it. Alexander Vilenkin gives the following example:

   > Suppose, for example, that [a] space traveler has
   > just zoomed by the earth at the speed of 100,000

> kilometers per second and is now headed toward a distant galaxy, about a billion light years away. That galaxy is moving away from us at a speed of 20,000 kilometers per second, so when the space traveler catches up with it, the observers there will see him moving at 80,000 kilometers per second [100,000 kps minus 20,000 kps].

Now let's extend Vilenkin's example. Suppose that there are observers on a more distant galaxy – twice as far away as the first galaxy (two billion light years from here). Its recessional velocity should be approximately twice as much as the first galaxy's recessional velocity (approximately 40,000 kilometers per second away from us). The observers on that galaxy would see the rocket coming at 60,000 kps (100,000 kps minus 40,000 kps).

As can be seen, relative velocity is inversely proportional to recessional velocities. So, the greater distance a galaxy is from us, the *greater* will be its recessional velocity; however, the *relative* velocity of a projectile approaching that more distant galaxy will be *smaller* than its relative velocity approaching a *nearer* galaxy. We can generalize by saying that the greater the distance of an object (such as a galaxy) is from a projectile (like a spaceship) moving toward it, the greater will be the recessional velocity of that object; however, the relative velocity of a projectile approaching it will be smaller (in inverse proportion to the recessional velocity).

3. The Third Step: There are two ways of having greater distance between our galaxy and other distant galaxies. The first way is the one described above (where galaxy #2 happens to be farther away than galaxy #1). The second way is by going into the *future*. Let us return to our example of the rubber band. If the universe is expanding like our rubber band, then every single moment our universe moves into the future, the recessional velocity of distant objects will get greater and greater. Remember our three dots: one at point zero, one at one inch, and one at two inches. When I pulled the third dot from two inches to four inches, the second dot only went from one inch to two inches. But now that the second dot is at two inches, it will do the same thing that the third dot did previously. It will now move from two inches to four inches in the same unit time. Thus, as our universe proceeds into the future, the recessional velocities of its galaxies will increase, because there is more space to expand (more rubber band to expand) between them.

4. The Fourth Step: now let's apply the above insight (about *recessional* velocities) to *relative* velocities. Recall that recessional velocity and relative velocity are inversely proportional; so if recessional velocities are *increasing* into the future, relative velocities of approaching projectiles must be *decreasing* into the future. Since all galaxies are moving away from each other (because the universe's spatial manifold is expanding as a whole), all relative velocities of objects will have to get slower and slower into the future.

5. The Fifth Step: what is the consequence of Step Four? If the relative velocities of all objects must be getting slower and slower into the future, they must have been faster and faster in the past. Vilenkin puts it this way:

> If the velocity of the space traveler relative to the spectators gets smaller and smaller into the future, then it follows that his velocity should get larger and larger as we follow his history into the past. In the limit, his velocity should get arbitrarily close to the speed of light.

So what is the point? It is not possible to have a relative velocity greater than the speed of light in our universe. Thus, when all relative velocities were arbitrarily close to the speed of light, then the past time of our universe could not have gone back any further. It represents a *beginning* of the universe.

Could this consequence of a beginning of the universe (in the Borde-Vilenkin-Guth Proof) be avoided if scientists discover a velocity higher than the speed of light in the future? No, because it does not matter what the upper limit to velocity is, it will always be reached in a finite proper time. The only thing that matters is that there *is* an upper limit to velocity in the universe (no matter what it is). This upper limit would have to be reached in a finite proper time, and so the universe would have to have a beginning in *any* expansionary scenario – irrespective of the true upper limit to velocity in it.

Let's suppose scientists discover a tachyon (a particle which can travel faster than the speed of light) next year. Suppose further that this tachyon can travel at twice the speed of light (600,000 kps). Would this affect the BVG Proof? No, because the relative velocities of all projectiles would have been increasing in the same fashion mentioned above throughout the universe's history, so at an earlier point in the universe's past, all relative velocities would have been 600,000 kps – which would again constitute a beginning (because the past time of the universe could not have existed before that point). We can postulate any finite velocity we want as the upper limit to velocity in our universe (or any other universe or a multiverse) and we can know with certainty that every projectile in that universe or multiverse would have been travelling at that relative velocity sometime in that universe's or multiverse's *finite* past. Every scenario *requires* a beginning.

Does *every* universe or multiverse have to have a *finite* maximum velocity? Yes, because if that finite upper limit did not exist, then physical energy could travel at an *infinite* velocity, in which case physical energy could be everywhere in the universe or multiverse simultaneously. This gives rise to two irresolvable problems – first, there would be a multiplication of the same physical energy at every space-time point in the universe which apparently contradicts the first law of thermodynamics (matter-energy can neither be created nor destroyed). This multiplication of physical energy leads to a second problem – namely, that every space time point would be simultaneously occupied by contradictory forms of energy (such as protons and electrons or matter and antimatter). The whole universe or multiverse would be filled with contradictions (an obviously impossible state of affairs). The avoidance of these problems requires a finite maximum velocity in every universe *and* multiverse (because every multiverse must be inflationary, and must therefore have an average expansion rate greater than zero). If all universes and multiverses must have a finite maximum velocity, and they also have an expansion rate greater than zero (the single condition of the BVG Proof), then they would also have to have a *beginning*.

There is one important nuance that should be clarified. The BVG Proof establishes a boundary. To the extent that classical gravity is operative near that boundary, the boundary is a singularity and therefore a beginning of time. However, if quantum gravity effects are important near that boundary (which would be the case in some scenarios) the boundary could merely be a gateway to another earlier region of space-time.[32] If the boundary represents only a transition to a new kind of physics, then the question arises as to whether that new physics is subject to a BVG boundary that is fundamental (such as a singularity or an absolute boundary to past time).

This is where the extensive general applicability of the BVG Proof comes into play, for inasmuch as the Proof applies to *any* universe with an average Hubble expansion greater than zero (independent of the physics of that universe), then the BVG Proof requires that a past-time boundary be present in any prior state of the universe which is expansive. Ultimately, an absolute boundary to all past expansive states will be reached (which would be a beginning of past time in the universe). There is only one way to avoid this beginning – a prior state which is eternally static (addressed below).

Borde, Vilenkin, and Guth consider some scenarios of prior universal states arising out of quantum gravity and inflation. One such scenario is inspired by string theory:

> Our argument can be straightforwardly extended to cosmology in higher dimensions. For example, in one model, brane worlds are created in collisions of bubbles nucleating in an inflating higher-dimensional bulk space-time. Our analysis implies that the inflating bulk cannot be past-complete [i.e. must have a boundary to past time]. ¶ We finally comment on the cyclic Universe model in which a bulk of four spatial dimensions is sandwiched between two three-dimensional branes…In some versions of the cyclic model the brane space-times' are everywhere expanding, so our theorem immediately implies the existence of a past boundary at which boundary conditions must be imposed. In other versions, there are brief periods of contraction, but the net result of each cycle is an expansion.…Thus, as long as $H_{av} > 0$ for a null geodesic when averaged over one cycle, then $H_{av} > 0$ for any number of cycles, and our

[32] See Borde, Guth, and Vilenkin. 2003 p 4. See also Craig and Sinclair 2009 p 142 (n 41).

> theorem would imply that the geodesic is incomplete [i.e. must have a boundary to past time].[33]

Notice that the extensive general applicability of the BVG theorem allows it to establish a past-time boundary for quite diverse models where quantum gravity effects play important roles. Notice also that the BVG theorem applies to this hypothesis even though it has a contracting phase, because all that is required for the applicability of the BVG Proof is that the *average* Hubble expansion be greater than zero (no matter how small the positive non-zero average might be). Since this hypothetical condition must have an *average* Hubble expansion greater than zero (amidst its many expansions and contractions), it must have a boundary to its past time.

Does the BVG theorem apply also to Linde's eternal inflation scenario? According to Borde, Guth, and Vilenkin, it does. Linde originally suggested that each bubble universe begins with a singularity and further suggested that these regional singularities might mitigate the need for a singularity in the whole array of bubble universes.[34] Craig and Sinclair explain why this does not escape the Borde, Vilenkin, and Guth Proof:

> Andre Linde has offered a critique, suggesting that BVG implies that all the individual parts of the universe have a beginning, but perhaps the WHOLE does not. This seems misconstrued, however, since BVG are not claiming that each past inextendible geodesic is related to a regional singularity. Rather, they claim that Linde's universe description contains an internal contradiction. As we look backward along the geodesic, it must extend to the infinite past if the universe is to be past-eternal. But it does not (for the observer commoving with the expansion).[35]

The extensive general applicability of the BVG Proof (whose only condition is an average Hubble expansion greater than zero) makes possible exceptions fall within a very narrow range. A possible exception will either (1) have to postulate a universal model with an average Hubble expansion *less* than zero (i.e. where average contraction is greater than expansion) or (2) postulate a universal model where the average Hubble expansion is *equal* to zero (what is termed an "eternally static universe").

Since models postulating an average contraction greater than expansion have proven to be physically unrealistic, physicists have turned to the "eternally static hypothesis" to find a way out of the BVG Proof. Vilenkin and his graduate student, Audrey Mithani, have demonstrated significant physical problems with this hypothesis (particularly quantum instabilities which force the static state to break down in a finite

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[33] Borde, Guth, and Vilenkin 2003 p. 4.
[34] See Linde 1998 p. 105.
[35] Craig and Sinclair 2009 p. 169.

time) in several important articles.[36] Additionally, the eternally static hypothesis falls prey to an irresolvable logical contradiction. Craig and Sinclair sum up the fundamental (and seemingly insurmountable) problem as follows:

> The asymptotically static hypothesis has the dilemma that it must begin static and then transition to an expansion. Hence, the static phase is metastable, which implies that it is finite in lifetime. The universe begins to exist.[37]

Craig and Sinclair point to a fundamental contradiction in the eternally static hypothesis. In order for a universe to exist in a static state for an infinite time, it would have to be *perfectly* stable. However, for a universe to move from one state to another, say, from a quantum cosmological or string theory state (before the Big Bang) to a state described by the General Theory of Relativity (after the Big Bang), the quantum cosmological state would have to have been *metastable* (not perfectly stable) to accommodate the decay of the first state into the second one. This implies that the hypothesis is contradictory – because the quantum cosmological state would have to have been *both* "perfectly stable (to last for an eternity)" and "not perfectly stable (metastable in order to decay into an expansive state)" prior to the Big Bang.

In sum, there are three consequences of the Borde-Vilenkin and Guth proof:

(i) It applies to all universes and multiverses (including bouncing universes in higher dimensions) that have an average rate of expansion greater than zero (no matter how small).
(ii) It does not matter what the physics of a given universe or multiverse might be; so long as the average Hubble expansion is greater than zero (because every universe or multiverse must have an upper limit to velocity).
(iii) Since there is only one condition for the proof to work and it functions independently of the physics of any given universe or multiverse, it will be very difficult to disprove.

At this point, it seems as if physics is coming very close to proving an absolute beginning of physical reality itself – whether physical reality is simply our universe, or perhaps a multiverse, or a universe in the higher dimensional space of string theory, or a static quantum cosmological state. If no physically realistic exception can be found to this proof (and to the problems of an eternally static universe), it would make an absolute beginning of physical reality quite probable. Vilenkin agrees with this assessment, and said in 2006:

> It is said that an argument is what convinces reasonable men and a proof [like the B-V-G Proof] is what it takes to convince even an unreasonable man. With the proof

[36] An excellent summary of this work can be found in Vilenkin's lecture to the physics community at Cambridge University on the occasion of Stephen Hawking's 70th birthday. See (http://www.newscientist.com/article/mg21328474.400-why-physicists-cant-avoid-a-creation-event.html).
[37] Craig and Sinclair 2009. P. 158.

> now in place, cosmologists can no longer hide behind
> the possibility of a past-eternal universe….There is no escape,
> they have to face the problem of a cosmic beginning.[38]

This takes us to the threshold of metaphysics. Before moving in that direction, we will want to first consider another vastly applicable datum that also indicates the likelihood of a beginning of physical reality – entropy.

IV.
Entropy and the Beginning of our Universe

Entropy is a technical concept that…. measures the degree of "disorder" or disorganization of a system. For purely probabilistic reasons, systems left to their own devices ("isolated systems") tend to evolve in a way that keeps the level of disorganization (entropy) constant or increases it. Almost never does the entropy of an isolated system decrease. Systems do not spontaneously get more organized. To make a system more organized takes something coming in from outside and expending energy (I can make the coffee in a cup hotter than its surroundings, for instance, by using a "heat pump" --- the opposite of a refrigerator --- to pump thermal energy from the cooler air into the hotter coffee. But that would require the expenditure of energy to run the heat pump).

The famous Second Law of Thermodynamics says that in isolated systems, entropy always increases or stays the same, and never goes down. That is why some processes are irreversible. If a process changes the entropy, then it can only go one way --- the way that entropy (disorganization) increases. That is why dead bodies decompose, but do not recompose! Of course, these are, ultimately, probabilistic statements. Entropy can have random fluctuations downward, but these are usually very tiny decreases, and the larger the decrease in entropy, the more unlikely it is to happen.

This is a universal phenomenon. It is why physicists regard "perpetual motion machines" as impossible. And here is the relevance to the question of whether the universe had a beginning. If the universe did not have a beginning, then it has been around for an infinite time. In a sense, the universe is then itself a "perpetual motion machine," a system that never "runs down" or "wears out," which is a violation of the Second Law of Thermodynamics. This argument against an infinite universe can be broken down into five steps:

1. For a physical system to do work, it needs to have order (disequilibrium)[39] within it. Variations of temperature (or other factors such as pressure or molecular distribution) within a system enable it to do physically useful work.

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[38] Vilenkin. 2006. p 176.

[39] "Order" generally refers to disequilibrium (such as variation in temperature, or differentiation of molecular distribution, or differentiation of pressure within a physical system). Since all thermodynamic systems tend toward equilibrium (the same temperature or distribution of molecules or pressure within a system), it follows that equilibrium is the most probable state of a system – and is considered the most disordered. In contrast to this, the more disequilibrium there is in a system, the more it is said to be ordered or organized (which is a more improbable state).

2. Every time a physical system does work it loses a small amount of its order (disequilibrium), which means that it is not capable of doing as much work as it could in its previous state. This movement from order to disorder is called "entropy."
3. For statistical reasons alone, entropy (the movement from order to disorder) is irreversible in the long term (though there may be random fluctuations toward lower entropy which do not and cannot last long).
4. If the universe is an isolated[40] physical system (the assumption of the standard Big Bang model), then the universe could not have existed for an infinite amount of time, because if it did, it would be at a state of maximum entropy (maximum equilibrium) today (for the reasons stated in 1-3 above). It would be a dead universe incapable of any work.
5. But the universe is not at maximum entropy (maximum equilibrium); there are hot stars and cold space, galactic clusters and empty space, and physical systems are continuously working – stars burning, planets forming, and physicists thinking about it.

Therefore, the universe has not existed for an infinite amount of time (and therefore has a beginning).

The evidence of entropy has one important quality in common with that of the Borde-Vilenkin Guth Proof, namely its vast applicability (seemingly to every physical system). It was stated earlier that the Second Law of Thermodynamics (entropy) is valid for statistical (mathematical) reasons alone. Therefore, it is applicable to a multiplicity of physical scenarios – and is theoretically applicable to virtually every physical system. Why? Because disequilibrium (order) is so much more improbable than equilibrium (disorder) and every physical system will always follow a line toward greatest probability – that is, toward disorder. Einstein was so certain of this that he declared,

> A law is more impressive the greater the simplicity of its premises, the more different are the kinds of things it relates, and the more extended its range of applicability.) [Entropy] is the only physical theory of universal content, *which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown."*[41]

There has been no shortage of attempts to elude this consequence of the Second Law of Thermodynamics (entropy). Several physicists have suggested that entropy might be lowered in a universal collapse ("a big crunch") or in a bouncing universe scenario. Both of these

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[40] "Isolated" here refers to a system acting on its own. There is no engine or refrigerator or heating element outside of the physical system that can introduce additional order (disequilibrium) within the system.
[41] Holton and Elkana 1997. p. 227.

suggestions have been virtually ruled out by the research of Roger Penrose,[42] Sean Carroll,[43] and Thomas Banks and Willy Fischler.[44] They also show that entropy makes virtually every form of the bouncing universe hypothesis untenable.[45] Though physicists are still hypothesizing new scenarios to elude a beginning of the universe from entropy, they are becoming more and more fantastic and further and further removed from the domain of observable evidence and the discipline of physics.

V.
From Physics to Metaphysics

The discussion in the two foregoing sections shows that the preponderance of cosmological evidence favors a beginning of the universe (prior to which there was no physical reality). This beginning of physical reality marks the point at which our universe (and even a hypothetical

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[42] As will be discussed below (Section V), Roger Penrose shows the virtual impossibility of low entropy at a bounce, because the odds against it are $10^{10^{123}}$ to 1 against its occurrence (the odds of a monkey typing Macbeth by random tapping of the keys in one try – this is a virtual impossibility). See Penrose. 1989. pp 343-344.

[43] According to Sean Carroll, a well-known cosmologist, the low entropy of our universe at the Big Bang invalidates an eternal bouncing universe hypothesis; it even makes a single bounce to be exceedingly improbable: "Bojowald uses some ideas from Loop Quantum Gravity to try to resolve the initial singularity and follow the quantum state of the universe past the [Big] Bang back into a pre-existing universe. If you try to invent a cosmology in which you straightforwardly replace the singular Big Bang by a smooth Big Bounce continuation into a previous space-time, you have one of two choices: either the entropy continues to decrease as we travel backwards in time through the Bang, or it changes direction and begins to increase. Sadly, neither makes any sense. If you are imagining that the arrow of time is continuous as you travel back through the Bounce, then you are positing a very strange universe indeed on the other side. It's one in which the infinite past has an extremely tiny entropy, which increases only very slightly as the universe collapses, so that it can come out the other side in our observed low-entropy state. That requires the state at *t* = minus infinity state of the universe to be infinitely finely tuned, for no apparent reason (the same holds true for the Steinhardt-Turok cyclic universe). On the other hand, if you imagine that the arrow of time reverses direction at the Bounce, you've moved your extremely-finely-tuned-for-no-good-reason condition to the Bounce itself. In models where the Big Bang is really the beginning of the universe, one could in principle imagine that some unknown law of physics makes the boundary conditions there very special, and explains the low entropy (a possibility that Roger Penrose, for example, has taken seriously). But if it's not a boundary, why are the conditions there [at the Bounce] so special? (Carroll 2007 p. 1).

[44] Banks and Fischler believe that a universal collapse will lead to a "black crunch" (maximum entropy) from which a low entropy bounce would be virtually impossible ($10^{10^{123}}$ to 1 against, according to Roger Penrose. See below Section V). In fact, things are probably even worse for models in which the Big Bang was a bounce preceded by a phase in which the universe was collapsing. It has been argued by the particle physicists, Banks and Fischler, that during such a collapse the rapidly changing space-time would have excited and amplified random "quantum fluctuations" in such a way that entropy would have been driven to very *large* values, rather than small ones. This makes it even more difficult to account for the fantastically low entropy just after the Big Bang. In Banks' words, ... "I have a problem with ALL cyclic cosmologies…. The collapsing phase of these models always have a time-dependent Hamiltonian for the quantum field fluctuations around the classical background. Furthermore the classical backgrounds are becoming singular. This means that the field theories will be excited to higher and higher energy states…. High energy states in field theory have the ergodic property--they thermalize rapidly, in the sense that the system explores all of its states. Willy Fischler and I proposed that in this situation you would again tend to maximize the entropy. We called this a black crunch and suggested the equation of state of matter would again tend toward $p=\rho$. It seems silly to imagine that, even if this is followed by a re-expansion, that one would start that expansion with a low entropy initial state, or that one had any control over the initial state at all." (Banks 2007 from a private communication to James Sinclair, October 12, 2007 in Craig and Sinclair 2009 p 156).

[45] See the previous three footnotes.

multiverse or a universe in the higher dimensional space of string theory) came into existence. Recall (from Section II above), that quantum gravity and inflation theory allowed for four major hypothetical extensions of physical reality beyond our observable universe and prior to our Big Bang – the multiverse hypothesis, the bouncing universe hypothesis, the eternally static universe hypothesis, and the higher dimensional space hypothesis. The foregoing analysis shows the high probability that all four of these hypothetical models have a beginning:

(1) Every multiverse hypothesis must be inflationary, subjecting it to the Borde-Vilenkin-Guth Proof, which entails a beginning in the finite past.

(2) Bouncing universe hypotheses fall prey to four major problems: (a) They are subject to the Borde-Vilenkin-Guth Proof (because their average Hubble expansion is greater than zero), (b) Carroll's requirement of "infinite fine-tuning for no apparent reason" in eternally bouncing universes (making them virtually impossible), (c) Banks' and Fischler's prediction that a single collapse will lead to a dark dead universe (maximum entropy), and (d) The probable flat geometry and preponderance of dark energy in our universe disallows the cessation of expansion into the future.

(3) The eternally static hypothesis falls prey to quantum instabilities according to Vilenkin and Mithani. It also appears to be intrinsically contradictory (perfectly stable and not perfectly stable prior to the Big Bang).

(4) The expanding and bouncing forms of the higher dimensional space hypothesis are subject to the Borde-Vilenkin-Guth Proof, which entails a beginning in a finite past time.

There are currently no truly satisfactory alternatives to this evidence for a beginning.[46] Is this evidence sufficient to show a beginning of *physical reality itself*?

If a beginning of physical reality is a point at which everything physical (including mass-energy, space and time, and physical laws and constants) came into existence, then *prior* to this beginning, all aspects of physical reality would have been *nothing*. It seems likely that this is the case, because quantum gravity, the General Theory of Relativity, and field theory all suggest that everything physical is interrelated[47] – if one aspect exists, then they all exist, and vice-versa. This means that prior to the beginning, physical reality was most likely nothing – physical space and time, physical mass and energy, and the laws and constants – every aspect of physical reality.

This encounter with "nothing" brings us into the domain of metaphysics, which many physicists have unwittingly entered because of the strong evidence for a beginning of physical reality. Stephen Hawking has recently claimed that spontaneous creation can occur from nothing,

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[46] Since the Borde-Vilenkin-Guth theorem rules out all expanding universes (or multiverses), and the entropy evidence rules out an eternal universe and all bouncing universes, and the static universe hypothesis is intrinsically contradictory and highly improbable in light of quantum instabilities, the only recourse left seems to be that of postulating "backward time" prior to the Big Bang (see Aguirre and Gratton 2002). Most physicists have unhesitatingly declared this hypothesis to be physically unrealistic because it enables physically unrealistic phenomena to occur – such as the sound of the clap coming before the clap.

[47] Some may think that space and time are not relevant in quantum gravity (e.g. String Theory or Loop Quantum Gravity), but in fact, they are. String Theory and Loop Quantum Gravity presume continuity, dimensionality, and temporal differentiation (space and time), but they are differently configured than in the General Theory of Relativity.

because of the law of gravitation and M Theory.[48] Alexander Vilenkin has a more developed view of Hawking's central point – that the universe tunneled from nothing (which turns out to be irresolvably problematic). He seems to recognize problems in this hypothesis, and backs into a position of "closet theism." William Lane Craig provides a summary and incisive critique of Vilenkin's argument in his review of Vilenkin's 2006 book *Many Worlds in One: The Search for Other Universes:*

> [Vilenkin] invites us to envision a small, closed, spherical universe filled with a false vacuum and containing some ordinary matter. If the radius of such a universe is small, classical physics predicts that it will collapse to a point; but quantum physics permits it to "tunnel" into a state of inflation… If we allow the radius to shrink all the way to zero, there still remains some positive probability of the universe's tunneling to inflation. Now Vilenkin equates the initial state of the universe explanatorily prior to tunneling with nothingness: "what I had was a mathematical description of a universe tunneling from zero size—from nothing!—to a finite radius and beginning to inflate" (p. 180). This equivalence is patently mistaken. As Vilenkin's diagram on the same page illustrates, the quantum tunneling is at every point a function from something to something. For quantum tunneling to be truly from nothing, the function would have to have a single term, the posterior term. Another way of seeing the point is to reflect on the fact that *"to have no radius" (as is the case with nothingness) is not "to have a radius whose measure is zero."* ¶ Vilenkin himself seems to realize that he has not really described the tunneling of the universe from literally nothing, for he says, "And yet, the state of 'nothing' cannot be identified with *absolute nothingness*. The tunneling is described by the laws of quantum mechanics, and thus 'nothing' should be subjected to these laws" (p. 181). It follows that the universe described by those laws is not nothing. Unfortunately, Vilenkin draws the mistaken inference that "The laws of physics must have existed, even though there was no universe" (p. 181). Even if one takes a Platonistic view of the laws of nature, they are at most either mathematical objects or propositions, abstract entities that have no effect on anything. (Intriguingly, Vilenkin entertains a conceptualist view according to which **the laws exist in a mind** which predates the universe [p. 205], the closest Vilenkin comes to theism).[49]

As Craig shows, Vilenkin implicitly recognizes his equivocation concerning the term "nothing" (Vilenkin 2006 p 181) and that this ultimately requires him to postulate the existence of physical laws independent of the universe. He also seems to recognize that these laws imply a transphysical mind or mentative state (Vilenken 2006 p 205), which, as Craig notes, puts him in the camp of implicit theism. In my view, Vilenkin's metaphysical foray is much more sophisticated than that of Hawking and Mlodinow, because they do not admit their equivocation about "nothing" and do not acknowledge that their transphysical laws (the law of gravitation and

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[48] "Because there is a law such as gravity, the Universe can and will create itself from nothing…Spontaneous creation is the reason there is something rather than nothing, why the Universe exists, why we exist" (Hawking and Mlodinow 2010 p 180).

[49] Craig 2009 pp 237-238.

M Theory) entail a transphysical mind or mentative state.[50] It seems that any attempt to hypothesize something coming from nothing will result in a host of problems – such as, "sneaking" something into nothing, equivocating on the term "nothing," and/or postulating an unacknowledged transphysical mentative state which allows laws (without physical reality) to generate the whole of physical reality. If we are to avoid these confusions, we should follow the example of Parmenides, and allow "nothing" to be nothing (the complete absence of reality). This means not putting any content into "nothing" such as continuity, dimensionality, or orientability (as might be found in a spatial manifold) or confusing "nothing" with physical laws without a physical universe (entailing an unacknowledged transphysical mind or mentative state). Anything else argues the most fundamental of contradictions.

We can know something else about nothing – namely, that it can only do nothing. As metaphysicians since the time of Parmenides have recognized, "From nothing, only nothing can come."

We may now proceed to our conclusion – combining a first premise from physics and a second premise from metaphysics.

(1) There is a high likelihood of a beginning of physical reality (prior to which physical reality was literally nothing).

(2) From nothing, only nothing comes (*apriori* true).

Therefore it is highly likely that the universe came from *something* which is *not* physical reality (i.e. beyond physical reality). This is commonly referred to as a "transcendent cause of the universe" (or "a transcendent cause of physical reality") – in short, "a Creator."

VI.
Fine-Tuning "for Life" at the Big Bang
Implications of Supernatural Intelligence

There are several conditions of our universe necessary for the emergence of any complex life form. Many of these conditions are so exceedingly improbable that it is not reasonable to expect that they could have occurred by pure chance. For this reason many physicists attribute their occurrence to supernatural design. Some other physicists prefer to believe instead in trillions upon trillions of "other universes" (in a multiverse which is unobserved and likely unobservable). Before discussing which explanation is more probative, we need to explore some specific instances of this highly improbable fine-tuning. We may break the discussion into two parts:

A. The exceedingly high improbability of our low entropy universe, and

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[50] At one time, Hawking did admit to the need for a transcendent cause beyond the laws of physics – "If we discover a complete theory, it would be the ultimate triumph of human reason – for then we should know the mind of God…Even if there is only one possible unified theory, it is just a set of rules and equations. What is it that breathes fire into the equations and makes a universe for them to describe?" Hawking 1988 p 174.

B. The exceedingly high improbability of the anthropic values of our universe's constants.

We will discuss each in turn.

VI.A.
The high improbability of a pure chance occurrence of our low-entropy universe

A low-entropy universe is necessary for the emergence, evolution, and complexification of life forms (because a high entropy universe would be too run down to allow for such development). Roger Penrose has calculated the exceedingly small probability of a pure chance occurrence of our low–entropy universe as $10^{10^{123}}$ to one against. How can we understand this number? It is like a ten raised to an exponent of:
1000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000.

This number is so large, that if every zero were 10 point type, our solar system would not be able to hold it! This is about the same odds as a monkey typing Shakespeare's *Macbeth* by random tapping of the keys in a single attempt (virtually impossible). Currently, there is no natural explanation for the occurrence of this number, and if none is found, then we are left with the words of Roger Penrose himself:

> In order to produce a universe resembling the one in which we live, the *Creator* would have to aim for an absurdly tiny volume of the phase space of possible universes—about $1/10^{10^{123}}$ of the entire volume, for the situation under consideration.

What Penrose is saying here is that this occurrence cannot be explained by a random (pure chance) occurrence. Therefore, one will have to make recourse either to a multiverse (composed of bubble universes, each having different values of constants) or as Penrose implies, a Creator (with a super-intellect).

VI.B.

The high improbability of other anthropic conditions (based on cosmological constants)

A cosmological constant is a number which controls the equations of physics, and the equations of physics, in turn, describe the laws of nature. Therefore, these numbers control the laws of nature (and whether these laws of nature will be hospitable or hostile to any life form). Some examples of constants are: the speed of light constant (c= 300,000 km per second), Planck's constant ($\hbar$ = **6.6×10^{-34}** joule seconds), the gravitational attraction constant (G = **6.67×10^{-11}**), the strong nuclear force coupling constant (g_s = **15**), the weak force constant (g_w = **1.43×10^{-62}**), the rest mass of the proton (m_p = **1.67×10^{-27}** kg), rest mass of an electron (m_e = **9.11×10^{-31}** kg), and charge of an electron proton (e = **1.6×10^{-19}** coulombs).

There are several other constants, but the above constants are sufficient to show the fine-tuning of our universe.

Before proceeding to some examples, it should be noted that the constants could have been virtually any value (higher or lower) within a very broad range at the Big Bang. However, the range of values of the constants that will allow for the development of a life form is exceedingly small (given the essential laws of physics and the mass of the universe). This means that any life form is exceedingly exceedingly improbable.

Notice also that the Big Bang is thought to be a boundary condition to natural causation in our universe, because what preceded the Big Bang was not the universe described by the General Theory of Relativity (with a space-time manifold), but rather what might be called "a quantum cosmological universe" (described perhaps by string theory or by loop quantum gravity). This hypothetical pre-Big Bang configuration would be causally *distinct* from the universe described by the General Theory of Relativity. This makes it very difficult to appeal to some kind of prior *natural* causation to account for the values of our constants and the low entropy of our universe at the Big Bang. It virtually forces physicists to answer the question with either a multiverse or supernatural design (explained below). We may now proceed to some examples of how the constants' values are fine-tuned for life.

1. If the gravitational constant (G) or weak force constant (g_w) varied from their values by an exceedingly small fraction (higher *or* lower) -- one part in 10^{50} (.00000000000000000000000000000000000000000000000001) then either the universe would have suffered a catastrophic collapse or would have exploded throughout its expansion, both of which options would have prevented the emergence and development of *any* life form. Paul Davies describes it as follows:

> If G, or g_w, differed from their actual values by even *one part in 10^{50}*, the precise balance against Λ_{bare} would be upset, and the structure of the universe would be drastically altered.[51]…[I]f Λ were several orders of magnitude greater, the expansion of the universe would be explosive, and it is doubtful if galaxies could ever have formed against such a disruptive force. If Λ were negative, the explosion would be replaced by a catastrophic collapse of the universe. It is truly extraordinary that such dramatic effects would result from changes in the strength of either gravity, or the weak force, of less than one part in 10^{50}.[52]

This cannot be reasonably explained by a single random occurrence.

2. If the strong nuclear force constant were higher than its value (15) by only 2%, there would be no hydrogen in the universe (and therefore no nuclear fuel or water, prohibiting the development of a life form). If, on the other hand, the strong nuclear force constant had been 2% lower than its value then no element heavier than hydrogen could have emerged in the universe (helium, carbon, etc.). This would have prevented the development of a life form from the periodic table (specifically carbon-

[51] Davies. 1982. p.107. Italics mine.
[52] Davies. 1982. p.108.

based life forms). Walter Bradley sums up Brandon Carter's research on this topic by noting:

> Brandon Carter in 1970 showed that a 2 percent reduction in the strong force and its associated constant would preclude the formation of nuclei with larger numbers of protons, making the formation of elements heavier than hydrogen impossible. On the other hand, if the strong force and associated constant were just 2 percent greater than it is, then all hydrogen would be converted to helium and heavier elements from the beginning, leaving the universe no water and no long-term fuel for the stars. The absolute value of the strong force constant, and more importantly, its value relative to the electromagnetic force constant is not "prescribed" by any physical theories, but it is certainly a critical *requirement* for a universe suitable for life.[53]

This "anthropic coincidence" also seems to lie beyond the boundaries of pure chance.

3. If the gravitational constant, electromagnetism, or the "proton mass relative to the electron mass" varied from their values by only a tiny fraction (higher *or* lower), then all stars would be either blue giants or red dwarfs. These kinds of stars would not emit the proper kind of heat and light for a long enough period to allow for the emergence, development, and complexification of life forms. Paul Davies outlines this coincidence as follows:

> What is remarkable is that this typical mass M_* just happens to lie in the narrow range between the blue giants and red dwarfs. This circumstance is in turn a consequence of an apparently accidental relation between the relative strengths of gravity and electromagnetism, as will be shown….This remarkable relation compares the strength of gravity (on the left) with the strength of electromagnetism, and the ratio of electron to proton mass…. Putting in the numbers, one obtains 5.9×10^{-39} for the left hand, and 2.0×10^{-39} for the right hand side. Nature has evidently picked the values of the fundamental constants in such a way that typical stars lie very close indeed to the boundary of convective instability. The fact that the two sides of the inequality are such enormous numbers, and yet lie so close to one another [10^{-39}], *is truly astonishing*. If gravity were *very* slightly weaker, or electromagnetism *very* slightly stronger, (or the electron slightly less massive relative to the proton), all stars would be *red dwarfs*. A correspondingly tiny change the other way, and they would all be *blue giants*.[54]

Again, this "anthropic coincidence" is inexplicable by a single random occurrence.

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[53] Bradley. 1998. p. 39. Italics mine. See also Breuer 1991. p 183.
[54] Davies. 1982. p 71-73. Italics mine.

4. Fred Hoyle and William Fowler discovered the exceedingly high improbability of oxygen, carbon, helium and beryllium having the precise values to allow for both carbon abundance and carbon bonding (necessary for life). This "anthropic coincidence" was so striking that it caused Hoyle to abandon his former atheism and declare:

> A common sense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question."[55]

The vast majority of physicists do not attribute these four and other anthropic coincidences (or the low entropy of the universe) at the Big Bang to random occurrence. Neither do they appeal to a prior natural cause (since the low entropy and constant values occur at the Big Bang). This virtually forces physicists to select one of two transuniversal explanations:

(a) A multiverse in which every bubble universe has its own set of constant values, ultimately allowing trillions upon trillions upon trillions of bubble universes with different values of constants to naturalistically produce one highly improbable anthropic universe like our own.

(b) Supernatural design in which a highly intelligent transphysical Creator selects the values of the constants and produces the low entropy of the universe at the Big Bang (similar to Sir Fred Hoyle's "superintellect").

Is the multiverse hypothesis more reasonable and responsible than supernatural intelligence? A combination of four factors implies that it is not. First, the other universes (and the multiverse itself) are in principle, unobservable (beyond our event horizon). Secondly, the multiverse hypothesis violates the principle of parsimony (Ockham's Razor) – the explanation with the least number of assumptions, conditions, and requirements is to be preferred (because nature favors elegance over needless complexity). As Paul Davies notes,

> Another weakness of the anthropic argument is that it seems the very antithesis of Ockham's Razor, according to which the most plausible of a possible set of explanations is that which contains the simplest ideas and least number of assumptions. To invoke an infinity of other universes just to explain one is surely carrying excess baggage to cosmic extremes … It is hard to see how such a purely theoretical construct can ever be used as an *explanation*, in the scientific sense, of a feature of nature. Of course, one might find it easier to believe in an infinite array of universes than in an infinite Deity, but such a belief must rest on faith rather than observation.[56]

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[55] Hoyle. 1981. pp. 8-12.
[56] Davies. 1983. pp. 173-174.

Though the first two reasons do not invalidate the multiverse hypothesis, they indicate problems for using it as a scientific or naturalistic explanation.

The third factor concerns the requirement that every multiverse have a beginning because every multiverse must be inflationary (have an expansion rate greater than zero), making it subject to the Borde-Vilenkin-Guth Proof. This means that no plausible multiverse could produce an unlimited number of bubble universes. Again, this factor alone does not invalidate the multiverse as a possible explanation for our highly improbable anthropic universe, because a multiverse could theoretically produce $10^{10^{123}}$ (or more!) bubble universes. However, when the above three factors are combined with the fourth, it raises serious doubts about the adequacy of the multiverse as an explanation of anthropic coincidences.

The fourth factor concerns fine-tuning in the multiverse itself. Currently, all known multiverse theories have significant fine-tuning requirements. Linde's Chaotic Inflationary Multiverse cannot randomly cough out bubble universes because they would collide and make the bubble universes inhospitable to life; the bubble universes must be spaced out in a slow roll which requires considerable fine-tuning in the multiverses initial parameters.[57] Similarly, Susskind's String Theory Landscape requires considerable meta-level fine-tuning to explain its "anthropic tendencies."[58] In view of the above four factors, many physicists consider the supernatural design hypothesis to be just as reasonable and responsible (if not more reasonable and responsible) than the multiverse hypothesis for explaining the occurrence of our highly improbable anthropic universe.

Some physicists and philosophers have tried to cast doubt on the supernatural design hypothesis by appealing to a seemingly logical problem – namely that a designer would seem to be more improbable than anything it could design. Richard Dawkins is the best known advocate of this position, and I have responded elsewhere to this erroneous contention.[59]

VII.
Conclusion
Combining the Physical and Metaphysical Evidence

In this paper we have discussed three kinds of evidence for the existence of an intelligent Creator:

1. Space-time geometry proofs for a beginning of physical reality (implying a causative power transcending physical reality).
2. The evidence from entropy for a beginning of our universe (and physical reality) implying a causative power transcending physical reality.
3. The fine-tuning of the initial conditions and constants of the universe at the Big Bang (implying supernatural intelligence).

57 See Alabidi and Lyth. 2006.
58 See Gordon. 2010 pp 100-102.
59 See Spitzer 2015 Appendix II.

Each of these three kinds of evidence has probative force in its own right (independently of the others). But when they are combined, they become complementary because they corroborate each other while emphasizing different dimensions of the one transcendent intelligent Creator.

John Henry Newman termed such a network of complementary evidence an "informal inference,"[60] that is, reaching a conclusion by considering the accumulation of converging antecedently probable data sets. For Newman, truth claims did not have to be grounded in an infallible source of evidence or in a strictly formal deduction. They could be grounded in the convergence (complementarity and corroboration) of a multiplicity of *probabilistic* evidential bases. Certitude is not grounded in one base alone, but in a multiplicity of likely or probable evidential *bases*. Thus, even if one (or more) of these bases undergoes modification, the certitude intrinsic to the convergence remains intact (though it may be lessened).

Space-time geometry proofs and entropy give *physical and scientific* evidence for a transcendent power creating our universe (and even a hypothetical multiverse or universe in the higher dimensional space of string theory). The evidence of the fine-tuning of initial conditions and constants of our universe complements the evidence of a creation by providing *physical* and *scientific* evidence of intelligence. In combination, they support the existence of a highly intelligent creative force of physical reality.

In my view, this "informal inference" represents the true vision not only of John Henry Newman, but also of St. Thomas Aquinas and Monsignor Georges Lemaître, showing the comprehensiveness and depth of the Catholic intellectual tradition.

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[60] Newman, 1992 pp 259-342 (Chapter VIII).

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