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Creatio Ex Nihilo as the Basis for a Set-Theoretic Cosmology

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✝***JMJ***✝

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Abstract

The principle of *creatio ex nihilo* is commonly predicated on the conception of 'nothing' as the absence of matter and reality, but this axiomatic presupposition about 'nothing' conflates 'the absence of matter' and 'the absence of reality,' A distinction between these is drawn to establish that in the absence of matter there is still an ontologically real logic-space; the necessity for which is established by examining O'Connnor's three ways to an ultimate explanation, and supported by analyzing mathematical parameters required to define physical systems in cosmology. Equating this logic-space with Leibniz's realm of ideas in the mind of God, a set-theoretic interpretation of Leibniz's ontology is then developed which depicts a cosmology whereby the universe is allowed to *subsist* as a logico-mathematical Leibnizian possible-relation-space (the logic-space). The universe is then modeled as a set (called the Null Set) in that logic-space, containing all the possible-relations from which the universe is subsequently created. *Creatio ex nihilo* is then not creation from 'nothing' *per se*, but rather creation from an ontologically real set which, although *physically* identical to 'nothing,' contains all the possible relations and entities required to define a physical universe.

Key words: Creatio ex nihilo, Leibniz, Cosmology

Introduction

I will establish that the philosophy of *creatio ex nihilo* should not be interpreted as creation of the universe from the absence of reality, but rather as creation from a mathematically pure and ontologically real structure of "abstract entities with relations between them,"[1] achieved by modeling the universe as a mathematical structure containing subsets of all physical things such that "our external physical reality is a mathematical structure."[2] Rejecting the established definition of *creatio ex nihilo* as creation from the absence of reality and without the use of preexisting materials,[3] I show that it ought to mean creation from the absence of physicality, not the absence of reality.

I'll employ Leibniz's conception of a realm of ideas in the mind of God, disagreeing with his equating of vacuum and void, and make a critical distinction between 'void' and 'nothing.' In so doing, Leibniz's rejection is reconciled by redefining 'void' as a logic-space devoid of physicality containing possible relations (i.e. the mind of God), not as a physical space containing nothing. Then, apart from Leibniz, I show that this void-nothing distinction is not new, but is central to the original and ancient conceptions of *creatio ex nihilo* found in the cosmology of Plato and in the biblical creation accounts.

The reality of this logic-space is supported by illustrating how physical relations in the world are predicated upon mathematical parameters, which I liken to Leibniz's 'eternal truths.' Predicating the physicality of the world upon *a priori* mathematics, I then analyze Dr. Timothy O'Connor's three ways of finding an ultimate explanation of things to establish the necessity for metaphysics. Having established the need for a metaphysic to obtain an ultimate explanation of the universe, and supporting that need with cosmological observations, I offer the idea of a set-theoretic cosmology as a possible response.

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[1] Tegmark, 2007
[2] Tegmark, 2007
[3] Erasmus, 2018

The Definition of Creatio ex Nihilo

Creatio ex nihilo is the doctrine which "maintains that matter is not external and that no matter existed prior to the divine creative act at the initial moment of the cosmic process."[4] The idea of creation from nothing first requires an explanation of what is meant by the term 'nothing.' Jacobus Erasmus claims creation from nothing "is the absence of reality. Thus, the expression 'without the use of preexisting materials' is preferable. … The doctrine of *creatio ex nihilo* (I shall hereafter omit 'the doctrine of') is, therefore, in stark contrast to the notion of *creatio ex materia* (creation out of matter)."[5] The principle of *creatio ex nihilo* is often refuted by the maintenance of *ex nihilo nihil fit*. This is found most prominently by the Roman philosopher Lucretius, who argued that *"nullam rem e nilo gigni divinitus umquam*"[6] (no thing is ever by divine power produced from nothing) and "*nil posse creari de nilo*"[7] (nothing can be created from nothing). However, Lucretius and Erasmus are arguing from a position which maintains that only matter ever begets matter, and since there is *only* matter and material things, there can be no non-material origin of those things so whatever is *real* must be material. While there is no objection to contrasting *creation from nothing* with the *creation from matter*, the implication is that 'nothing' is the absence of preexisting materials and that this is ontologically equivalent to the absence of reality. Herein I reject this equivalence of matter and reality, and demonstrate not only that a Leibnizian 'possible-relation-space' (or mind of God) is required to understand the concept of *creatio ex nihilo*, but that such an understanding of *creatio ex nihilo* is consistent with modern cosmology.

If *creatio ex nihilo* is, as William Craig claims, the affirmation "that without God's initiating creation, only God exists,"[8] then *creatio ex nihilo* is the instantiation of the universe, and spacetime, itself. So if 'nothing' is the "absence of reality" and creation from nothing implies that only God exists prior to the instantiation of the material universe, then there is an absence of reality whilst there is simultaneously an existing God — but if God is in some way a part of reality, then both cannot simultaneously be true. For this reason we must either reject the

[4] Bunnin et al., 2004
[5] Erasmus, 2018
[6] Lucretius et al., 1982
[7] Lucretius et al., 1982
[8] Erasmus, 2018

existence of God, reject the above given standing definition, or reject the concept of *creatio ex nihilo* altogether.

God cannot simply be replaced by some other mechanism of creation (a Big Bang, inflationary quantum bubbles, etc.) since there must be some underpinning entity by which the observable universe came into being, and so there can be no prior absence of reality. So while not proof of the necessary existence of a deity, rejecting such a deity does not lend itself to a more thorough ontology; indeed, such an ontology would regress *ad infinitum*. But rejecting the principle of *creatio ex nihilo* altogether is to effectively adopt the principle of *creatio ex materia*, and one will quickly run into the same problems as the rejection of a deity: there must then be some material entity by which the observable universe came into being, then another material entity as the progenitor of that one, *ad infinitum*. Rejection of a deity and rejection of *creatio ex nihilo* altogether then seem imprudent.

So it becomes tempting to adopt something akin to Goldschmidt's view which would effectively reinterpret Erasmus' "absence of reality." For Goldschmidt the void from which the universe came is rather "something like an empty spacetime, a totally dark and vast abyss."[9] In this view one never removes "reality" from the ontology, but rather maintains some sort of empty spacetime-like entity which can be populated by material existence. However, this definition stems from a critical presumption we have about void — namely, that 'void' (the absence of spatiotemporal reality) and 'nothing' (the absence of material things, or matter) are the same. This prevailing paradigm in which philosophers view *creatio ex nihilo* conflates the absence of the material with the absence of being (i.e. reality) itself. For example, if one accepts that there are no preexisting materials with which to furnish a wooden table, this absence of preexisting material to build a table does not necessarily entail the absence of the reality of 'a table' or 'tableness' in-and-of-itself. In other words, in the absence of a material and spatiotemporal universe there still remain the abstractions and relations by which matter is permitted to take form.

[9] Goldschmidt & O'Connor, 2013

Leibniz's Spacetime

Indeed, Leibniz held a similar position and maintained that there must be a distinction between the material things themselves and the abstractions by which things have meaning. In his correspondence with Samuel Clarke, Leibniz asserts "space to be something merely relative, as time is; that I hold it to be an order of coexistences, as time is an order of successions."[10] Leibniz is clear to not equate matter and space, but only that "there is no space, where there is no matter; and that space in itself is not an absolute reality. Space and matter differ, as time and motion."[11] Whereas motion occurs in time, so too does matter occur in space; without motion there is no time, and without matter there is no space. However, Leibniz concludes that "it does not at all follow, that matter is eternal and necessary; unless we suppose space to be eternal and necessary."[12] Of course, Leibniz didn't have the same conception of space and time that modern cosmology does: namely, that they are bound together in a fabric of spacetime. But his argument translates well into the modern cosmological understanding: as there must be space in order to have time and without space there is no time, in order to have an eternal time, there must then be an eternal space. So again it can be said that the only way for matter to be eternal and necessary is if "we suppose space to be eternal and necessary."[13]

One could reject the idea of an eternal space on the grounds that no matter exists for eternity, which will be addressed later in the discussion on O'Connor's Way of Eternity. But this rejection may then foster a renewed definition of space which is Leibnizian. As Dr. Jeffrey K. McDonough writes:

> "Unlike the relationship between, say, a mighty oak and its leaves, a genealogical tree is not something which exists as a thing independently of, and prior to, its members, but is itself rather something like an abstract system of relations holding between brothers, sisters, parents, children, aunts, uncles, etc. Analogously for Leibniz, space and time are not to be thought of as containers in which bodies are literally located and through which they move, but rather as an abstract structure of relations…"[14]

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[10] Leibniz, 1956a
[11] Leibniz, 1956b
[12] Leibniz, 1956b
[13] Leibniz, 1956b
[14] McDonough, 2019

If actual dimensional space is what arises from the structure of relations between physical things, then there needs to be a possible-relation-space in which possible relations subsist. This possible-relation-space one could call 'the mind of God.' In his *Theodicy* Leibniz asserts that the universe is the best of all possible worlds and that "there is an infinitude of possible worlds among which God must needs have chosen the best, since he does nothing without acting in accordance with supreme reason."[15] Of course, this then presupposes a plurality of possible worlds which were never selected by God and in which nothing was actualized, but which simply subsist in the mind of God.

Since "there is no space where there is no matter,"[16] Leibniz rejects the existence of vacuum and any concept of a void, and because of this it is critical to address a required change in verbiage. Whereas the Newtonian would assert that there exists the concept of a material space unoccupied by matter (i.e. vacuum), Leibniz and I maintain that in the absence of matter, all that remains is a pure logical space wherein possible or potential relations between potential things subsist — this is the mind of God. But this is not nothing *per se*, it is rather a possible-relation-space devoid of materially actualized things, but I shall begin to diverge from Leibniz's phraseology and call this possible-relation-space (i.e. mind of God) a 'void.' Whereas Leibniz equates and rejects void and vacuum, I separate the two terms to draw a critical distinction in the *creatio ex nihilo* philosophy: the distinction between 'void' (the absence of spatiotemporal reality and sole existence of the mind of God) and 'nothing' (the absence of material things, which Leibniz would call vacuum). This verbiage better accommodates a critical reading of other ancient texts which establish this redefined concept of 'void' within the *creatio ex nihilo* doctrine.

The 'Void' vs 'Nothing' Distinction in Scripture and History

The distinction between void and nothing is a necessary element of *creatio ex nihilo*, and indeed the principle of *creatio ex nihilo*, upon which religious scripture is predicated, maintains this distinction. Of course, the Bible contains two sources discussing creation of the universe —

[15] Leibniz et al., 1985
[16] Leibniz, 1956b

Genesis and the Gospel of John — but Proverbs also discusses critical elements of the creation. Genesis 1:1 teaches that "in the beginning God created the heaven and the earth," but of course the implication of this is twofold: that God already exists so that he could proceed to create anything in the first place, and that God is external to the universe He is creating. In Proverbs 8:23 we read that wisdom was "set up from eternity, and of old before the earth was made," confirming some state ontologically prior to the universe itself. However, if "only God exists"[17] prior to creation as Mr. Erasmus argues, and is ontologically prior to the universe, then God is this proverbial wisdom. Of course, this is precisely the message John conveys in the first chapter of the Gospel of John; relating Christ to the Word, in line with Jewish wisdom tradition.

According to John 1:1 there was only λόγος in the beginning, which was with God and in fact is God. Understanding that God created the universe, John is in fact equating λόγος to God and is not only personifying λόγος (or as St. Jerome translated it, *verbum — the word*), but stating that the universe was created from λόγος, and so was created from the very essence of God. In other words, the universe proceeded from God the λόγος. John is simply explicating the logical conclusion of Genesis and Proverbs, that Christ as "the Word Incarnate" is God and so is the wisdom that "was set up from eternity, and of old before the earth was made" (Proverbs 8:23).

In Genesis 1:2 the creation account explains that the earth was formless (תֹּהוּ [tohu]) and void (וָבֹהוּ [wabohu]).[18] However, in Job 26:7 we see this same verbiage and that there is a distinction being made between the "empty space" (תֹּהוּ [tohu]) and the "nothing" (בְּלִי־ [beli]). If the universe proceeded from God the λόγος, and Genesis is saying that the earth was merely devoid of things, but not that there was 'nothing' *per se*, then the scriptural account of creation maintains that the universe was created from λόγος itself, not from 'nothing,' and so the universe was formed by God out of some sort of transcendent a priori logic-space, which is God Himself. Scripture is asserting that God is the ontological structure of Creation and that this structure is eternal; or in modern parlance: God is the logic-space by which any ontology has meaning.

[17] Erasmus, 2018
[18] Genesis 1:2

Indeed, and perhaps unsurprisingly, this begins to parallel the philosophy of the ancient Greek world. We see Plato discuss the origin of the universe in the *Timaeus*, wherein he argues that there is a creative deity who ordered the world from a primeval chaos (χάος). Plato's deity was an intellect (*νοῦς*) which ordered the chaos,[19] but did not create the material universe from 'nothing' *per se*. So while the creative deity in the *Timaeus* is not in this sense the same sort of creative deity in the Bible, the underlying principle is in fact the same: that there is a distinction between the absence of anything and the absence of order or form. Indeed, this is the same principle developed by Leibniz: distinguishing between the absence of any things and the absence of the mind of God.

John's Gospel doesn't claim that "in the beginning was the chaos [τὸ χάος]", but the verbiage in scripture is consistent with the idea that the universe wasn't created from 'nothing,' but rather from word/thought/logical structure (which is John's λόγος and Plato's νοῦς) embodied by a deity that provides the eternal structure in which the universe came to be. Just as the Biblical Creation is predicated on the logic-space that is God, the "creation" of the universe for Plato is still predicated on some sort of eternal logic-space, which he simply called νοῦς. Neither John's λόγος nor Plato's νοῦς were 'nothing' *per se*, and both predicated the creation of the universe on some sort of transcendent logic-space. It follows that while the concept of 'nothing' meaning the absence of anything may exist, the universe did not stem from 'nothing'; there must then exist a distinction between 'nothing' and 'void,' which I've redefined as the mind of God from which the universe stemmed.

The Logic-Space as Leibniz's Mind of God

This logic-space upon which the creation of the universe is predicated is a real ontological space (akin to Plato's realm of the Forms) which is prior to physical space. It is the space in which relations between concepts subsist and physical relations (i.e. relations between possible physical things) have meaning and are defined. Remembering that God is this space, then it is easier to conceptualize by returning to the biblical parlance: the creation of the universe is predicated on God who gives meaning to all things. Once God thought the logical structure of

[19] Mason, 2006

the universe (i.e. laws of nature, mathematics, etc.), the material universe was able to form in accordance with those thoughts (i.e. laws of nature). But now this biblical phraseology is simply translated as: the universe is predicated on a logic-space which defines relations between physical things. As this space defines the logical structure by which all physical interactions must occur (i.e. laws of nature, mathematics, etc.), the material universe was able to form in accordance with those laws.

This view maintains a dichotomy between the physical universe and a metaphysical logic-space, without which there could be no defined relation because the physical system is beholden to its logico-mathematical parameters. This logic-space is the possible-relation-space that Leibniz requires, and he writes in *The Monadology* that "if there is a reality in essences or possibilities, or rather in eternal truths, this reality must needs be founded in something existing and actual."[20] Translating into modern parlance, Leibniz's 'eternal truths' are really the logico-mathematical parameters which define physical systems. So to say that if there is a reality in eternal truths, then that reality must be founded on something existing and actual, is to say that if there is a reality in the logico-mathematical parameters, then their reality must be founded on something existing and actual. However, since the logico-mathematical parameters are predicated on a subsistent logic-space (i.e. mind of God), then that logic-space must be existing and actual.

To illustrate this, consider the nucleus of the atom. The atom is held together by a combination of forces, and the electro-magnetic force is responsible for the attraction of the electron cloud to the nucleus of the atom. If the Sommerfeld constant, α, were increased then the permittivity of free space (ε_0) would decrease, causing the strength of the electric field to increase by a factor of:

$$\frac{\alpha \hbar c}{e^2}$$

This would cause electrons to more strongly attract to the nucleus, disrupting the structure of the atom, chemical reactions, lightwave propagation, and so much more. The whole physical system of all chemistry in the universe is bound to the Sommerfeld constant, but there is no chemical or

[20] Leibniz & Latta, 1898a

other physical means to change the constant itself: the mathematical parameters to which the laws of chemistry and physics are bound exist prior to, and independent of, the physical system they define.

As the system's mathematical parameters subsist within this logic-space, then the logic-space itself must also exist prior to, and independent of, the physical system. Since this logic-space is the space in which relations between physical things are defined, and so have meaning, it stands that the ultimate reason for things existing must also be independent of those things. In *De rerum originatione radicali*, Leibniz defends his claim that nothing in the world can be the ultimate reason for things, asserting that "cannot find in any of the individual things, or even in the entire collection and series of things, a sufficient reason for why they exist."[21] Leibniz argues that when we "imagine that the world is eternal [we] assume only a succession of states, and since no reason for the world can be found in any one of them whatsoever (indeed, assuming as many of them as you like won't in any way help you to find a reason), it is obvious that the reason must be found elsewhere."[22] He argues that the existence of the world is merely a succession of physical states which proceed "in accordance with certain laws of change,"[23] and to ascertain the reason for these changes one must look to the *a priori* explanation of those very laws of change. As such, the ultimate origin must "lie hidden in something extramundane"[24] and external to the physical world.

It is not the physical interactions of things which explain their origins, it is the laws by which that thing interacts with other things that will explain its origin. For example, if I'm sitting under a tree and an apple falls on my head, it's not that the apple fell on my head which allows me to explain where it came from; it's the understanding of the law of gravitation in this possible world that allows me to deduce the apple fell from a height, and so its origin must have been a branch of the apple tree under which I'm sitting. While I should come to conceptualize gravitation by observing my environment and understanding how things interact, my mind is performing calculation to discern from where the apple fell. If the apple were to have penetrated

[21] Leibniz et al., 1989
[22] Leibniz et al., 1989
[23] Leibniz et al., 1989
[24] Leibniz et al., 1989

the ground and produce an impact crater, I wouldn't be inclined to think it fell from the tree, but rather a much higher height or some other source all together. In this determination there was some degree of calculation of requisite force to produce the observed effect. While I interact with the environment by physical observation, my understanding of the reason for the environment only comes from mathematical modeling and calculation. Therefore, and to quote Leibniz, the reason for the world and all things in it stems from something "different from the chain of states, or from the series of things, the collection of which constitutes the world. And so we must pass from physical or hypothetical necessity, [to] to something which is of absolute or metaphysical necessity."[25] As these metaphysically necessary things involve "a certain Divine Mathematics or Metaphysical Mechanism,"[26] it is clear that Leibniz is arguing for this same logic-space in which physical relations are able to be defined. Furthermore, it is evident that these metaphysical definitions of relations subsist in "a certain realm of ideas, so to speak, namely, in God"[27] and that Leibniz is tacitly arguing for a logic-space which is the mind of God. However, as I've established earlier that *the universe proceeded from God the λόγος*, it stands that if this logic-space is also the λόγος and God is the λόγος, then this mind of God must also be God Himself.

O'Connor's Ways of Eternity, Unification and Plenitude and the Need for Metaphysics

Upholding the necessity of this metaphysical logic-space is to tacitly reject the notion that metaphysical entities are imaginary things which ought to be disregarded ultimate explanations of the universe. In this, we find that the principle objection to the set-theoretic ontology soon to outlined is no different than in 1697 when Leibniz posited the possible objection that "the heavy bodies striving really exist, while possibilities or essences before, or rather outside of existence, are imaginary or fictional, and therefore, one cannot seek a reason for existence in them."[28] However, he maintained that the existence of these essences (or metaphysical definitions of relations as this paper calls them) really exist in "a certain realm of ideas."[29] Unknown to Leibniz

[25] Leibniz et al., 1989
[26] Leibniz et al., 1989
[27] Leibniz et al., 1989
[28] Leibniz et al., 1989
[29] Leibniz et al., 1989

in 1697, cosmology and physics would soon begin to converge on precisely that idea, which I will soon address.

While Leibniz and I require a certain 'realm of ideas,' or 'logic-space' as I will call it, I'll consider this potential counterargument that metaphysical entities, such as this logic-space, are fictional and so are no use in determining the reason for existence or ultimate explanation. If that is true, then one must ask the question: is it possible for science to produce an ultimate explanation? Dr. Timothy O'Connor of Cornell University outlines three principle ways by which we may come to an ultimate explanation: the Ways of Eternity, Unification, and Plenitude.[30]

The Way of Eternity is "the attempt to provide an adequate theory on which physical reality had no beginning."[31] In effect, this is simply *reductio ad infinitum* as to have no beginning to continue some sort of physical process for eternity. However, an explanation must serve to provide a sensible description to the human mind, and appeal to infinite regress is not an explanation of anything. If this universe is in fact infinite in age and simply exists for eternity, the question of origin still remains: do the laws of the universe change and are the physical processes in the observable universe constant? What begot the observable universe? What were the prior parameters which ordained the current observables in the universe? Simply relying on the infinitude of the universe to maintain that there is no origin point is no explanation at all. Furthermore, it seems that the Way of Eternity is not possible because a physical universe existing for eternity appears to violate the known laws of physics. If the evolution of the universe is a reversible process, then the second law of thermodynamics states that the change of entropy of the universe is zero.[32] However, if the evolution of the universe is an irreversible process then the entropy of the universe must increase, and so if the evolution of the universe is an irreversible process and is infinite in age, then it must have infinite entropy.

Recently, the James Webb Space Telescope (JWST) has confirmed the expansion rate of the universe and appears to confirm the expansion of the universe measured by Hubble,[33] and

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[30] Goldschmidt & O'Connor, 2013
[31] Goldschmidt & O'Connor, 2013
[32] National Aeronautics and Space Administration, Second Law - Entropy
[33] Cesari, 2023

this has critically important philosophical conclusions. One of the parameters directly linked to that expansion was measured in 2018 by the Planck Science Team — the cosmological constant. This constant is widely used and defined as

$$\Lambda = \frac{3H_0^2}{c^2}\Omega_\Lambda,$$

from which it is clear that if ratio (Ω_Λ) between the cosmological constant energy density and the critical density of the universe is positive, then the cosmological constant (Λ) must be positive. The 2018 results found that the value of Ω_Λ is about 0.6889 and is positive.[34] Understanding that the maximum entropy the universe can obtain is "given by the entropy of a de Sitter space, whose size is determined by the cosmological constant,"[35] and knowing that the entropy of de Sitter space can be expressed by[36]

$$S = \frac{\pi}{2G}\sqrt{\frac{1}{\Lambda}},$$

then (since we now know the cosmological constant to be positive) we can see that the universe must approach a positive finite entropy and with this relation it's easy to see that a finite cosmological constant (Λ) requires a finite entropy (S).

Although Dyson et al. seem to agree that a positive cosmological constant entails a finite universe, they assert that their "assumptions — together with the existence of a final cosmological constant — imply that the universe is eternal but finite,"[37] but this position is philosophically problematic. Firstly, if spacetime is the very fabric of time itself, then a finite spacetime should entail a finite universe; but they claim an eternal universe. Secondly, since we know this nonzero entropy of the universe entails that the evolution of the universe is an irreversible process,[38] then if the evolution of the universe is an irreversible process and is infinite in age, the universe must have infinite entropy. However, with a finite and positive cosmological constant (Λ), the universe's entropy is not infinite, but rather will obtain a maximum value. Therefore, the universe appears to not be infinite in age (i.e. eternal) and so the

[34] Aghanim et al., 2021
[35] Dyson et al., 2002
[36] Maldacena & Strominger, 1998
[37] Dyson et al., 2002
[38] Patel & Lineweaver, 2019

Way of Eternity cannot be substantiated by the current *ΛCDM* cosmological paradigm. To argue that "physical reality had no beginning"[39] is no longer a tenable position since the universe according to Dyson et al. is finite, and we've just established that it cannot be eternal. So the Way of Eternity as an approach to an ultimate explanation must be abandoned.

Secondly, O'Connor's Way of Unification is "the attempt successively to reduce physical theory's number of fundamental properties and property bearers, and the laws governing their co-evolution through spacetime."[40] Again, a reductive approach which does not provide any explanation for the things that have been discovered or derived by that reduction. Consider the fundamental equation $F = ma$. This had been derived from Sir Isaac Newton's reduction of the mechanical world, and is the successful reduction of the theory of force to the fundamental properties of mass and acceleration. However, without understanding what mass and acceleration are themselves, this is not an ultimate explanation of force itself. Lacking in this reduction of force to its component properties, is a definition of time in which velocity may take place, dimensionality by which the derivative of velocity is understood to establish acceleration, and the Higgs field by which mass becomes an observable.

In the paradigm of Newtonian mechanics, the law described by the equation $F = ma$, was a sufficient explicans for the explicandum of force. However, as paradigms shifted and modern physics emerged with modern cosmology, the Newton paradigm was deemed insufficient as new explanations for that Newtonian explicans were required. Within the framework of the Newtonian paradigm, Newton and his colleagues were wholly unaware of the existence of atoms, fermions, and the need for something like a Higgs field. So, what was esteemed as an ultimate explanation of gravity and force generally, was in fact, very far from an ultimate explanation of that fundamental force. The overarching problem with these reductive approaches to some ultimate explanation is that for any given paradigm there appears to be currently unknown explanations of the explicans for a particular explicandum. As another layer of complexity is uncovered by a paradigm shift, and other explicantia are developed, there is never a mechanism available to establish when (or if) there remain more layers to be discovered. Since

[39] Goldschmidt & O'Connor, 2013
[40] Goldschmidt & O'Connor, 2013

there will never be certainty that there isn't yet another required paradigm shift, the Way of Unification can never provide a truly ultimate explanation.

Finally, O'Connor offers the Way of Plenitude which is "the attempt to provide complete explanation not by burrowing down to simple foundations or pushing back in beginningless time but by spreading out."[41] This way attempts to establish an ultimate explanation "through the devising of an elegant and empirically adequate theory that locates our universe within a vast structure of totalities that exhibits completely non-arbitrary properties."[42] However, since we cannot observe this vast structure of totalities, and so must rely on our mathematical assessment of it, in which to place our physics, this way will naturally impose a theory mathematically consistent with empiricism. O'Connor further argues that "if we seek a complete explanation of existence, we must pass from physics to metaphysics"[43] because all three of these ways have an unconditional explanation. His Way of Plenitude still requires an "empirically adequate theory"[44] which will necessarily be predicated on the empirical observations of our universe which are themselves (as discussed in the Ways of Eternity and Unification) founded upon some sort of unanswerable physical origin. So the Way of Plenitude requires the physical world to ultimately explain the origins of the physical, and to escape this circularity there must be an appeal to metaphysics or theology.

Of course the sciences certainly have a hand in determining what is the case in the universe, but it does not appear to be possible for science alone to produce and ultimate explanation. As such, the counterargument that metaphysical entities are fictional and useless in determining the reason for existence seems to fail. If science alone cannot then produce an ultimate explanation, and there must be an appeal to metaphysics or theology, then this set-theoretic cosmology may yield an ultimate explanation of the universe.

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[41] Goldschmidt & O'Connor, 2013
[42] Goldschmidt & O'Connor, 2013
[43] Goldschmidt & O'Connor, 2013
[44] Goldschmidt & O'Connor, 2013

The Universe as a Set-Theoretic Model in the Logic-Space

I maintain that the need for metaphysics can be satisfied by treating the universe as an ontologically *real* and mathematically pure set, rather than as an exclusively material thing, just like Leibniz's realm of ideas. Accepting that *creatio ex nihilo* scripturally and historically has maintained the existence of some sort of eternal logic-space, not unlike Plato's realm of the Forms or Leibniz's realm of ideas, then O'Connor's metaphysical solution can be found in this logic-space. Furthermore, the historical and Scriptural depictions of the universe and Creation are even consistent with this mathematical interpretation of cosmology, such that the universe could have emerged not from non-existence (i.e. "nothing") but from a null-existence (i.e. "void").

In Leibniz's words we might say that the universe is really built upon a set of eternal truths in the mind of God; the eternal truths (such as 'the sum of two and two is four') are true in all possible worlds and all possible worlds are in the mind of God. This would translate into a set-theoretic paradigm as saying that the universe is really built upon a mathematical set of facts (i.e. logico-mathematical parameters) and that "mathematical existence equals physical existence"[45] where "our external physical reality is a mathematical structure."[46] When those facts (e.g. scalar points in the Higgs field giving particles mass, or tensor-spaces describing physical environments) are removed from the universe all that remains is a set (which I shall call the Null Set) that contains all the subsets of the universe with 0 values, and the empty set (which of course comes from the elementary proof that the empty set is a subset of every set). As opposed to then presuming the Null Set is a set that does not really exist, I posit that it is very much a real entity in and of itself and is merely a set of null values. This Null Set would then subsist in the logic-space required in the ontologies of the ancient philosophers, Scripture, Leibniz, and many others. Within the logic-space which that paradigm seems to require, we can construct an ontology in which the universe itself is defined as a set of all points (i.e. facts)[47] in spacetime. Recognizing that all things in the universe are fundamentally described by tensors and vector spaces, we can define mathematically any given thing in the universe (be it a force, a particle, or

[45] Tegmark, 2014b
[46] Tegmark, 2014a
[47] These points could be thought to be Leibniz's monads.

a system of interacting particles and forces), and ascribe to the particular system in question a mathematical set of all the logico-mathematical parameters of that system.

A simple example would be a point particle. Given a point particle defined by a wavefunction, p, at any given instant, x^0, existing within some spatial coordinate system $\{x^1, x^2, x^3\}$. This set will then contain an element corresponding to the point particle itself, and then the four spatiotemporal coordinates it requires to define its instantaneous place in spacetime, and is denoted:

$$A \equiv \{p, x^0, x^1, x^2, x^3\} \qquad \text{(Eq. 1)}$$

As such, we shall call this set, A, an 'atomic set,' and every object in the universe is a superset, O (the set of all objects), of the atomic set. Objects therefore exist in a finite space at a time, t, and this fact comes into play when we define a place. A place is said to be void if there are no material objects in that place. In other words, a place, P, is void at a time, t, *iff* there is no object such that:

$$\langle O, t\rangle \in P \text{ where, } A \in O \qquad \text{(Eq. 2)}$$

This now begins to differ from Leibniz's view which equates void and vacuum and then rejects them altogether, as this model (maintaining the void-nothing distinction made earlier) allows the vacuum to be defined. By treating a space as the superset of places we can then similarly define a physical space, V, as being a vacuum at a time, t, *iff* every place $P \in V$ is void of material things at time t. Mathematically, we say that: for all places, there does not exist an object such that, if there is an object at time, t, in place, P, then P is an element of the vacuum set. Symbolically this is expressed as:

$$\neg \exists x \, \forall P \left\{ \langle x, t\rangle \in P \iff P \in V \right\} \qquad \text{(Eq. 3)}$$

But of course this simply formalizes the definition of vacuum as being a space in which there exist no material things, and says nothing about whether or not a vacuum actually exists.

This then allows us to define the universe as the set, V, of all places and it becomes possible to define a vacuous universe — i.e. a 'null universe.' Such a state, although void of physicality and so *physically non-existent*, is not a state of non-existence: it subsists in the logic-space, meaning to have ontological reality in a state differing from actualized/physical existence, maintaining in a state that is prior, or fundamental, to actualized/physical existence (i.e.

belonging to the class of entities contained in the mind of God). In this, the set-theoretic approach may reconcile Leibniz's rejection of the vacuum. The set-theoretic approach maintains that the vacuum may, or may not, itself exist actually; but regardless of its existence the need for a subsistent logic-space (i.e. mind of God) maintains. We say that for all places, if it is the case that the Universe Set contains the set of all places and the set of all places is an element of the vacuum set, then the Universe Set is itself an element of the vacuum set:

$$\forall P\{U(P) \wedge P \in V \Rightarrow U \in V\} \qquad \text{(Eq. 4)}$$

Importantly, this is precisely the state of the universe we find as we rewind the evolutionary clock. Whilst the mechanism by which the universe came into existence may not yet be known, it can be said that the universe still subsisted as the set U and an element of the vacuum set V, prior to it generating the elements of A and O, which then populated the universe providing U with a non-null value. That is to say, in the beginning (i.e. the instant 'before' the Big Bang, or whatever it was) the universe contained only the empty set and the subset P, with $P = 0$, and so V was a species of the Null Set.

Now, the empty set and the Null Set (denoted $\mathfrak{N}$) are different. Whereas the empty set is a set with no elements, the Null Set is an ontologically real superset of the empty set and all other subsets of the Universe Set, U, with elements of value 0. In effect we have the following, the empty set is a subset of the Universe Set:

$$\{\varnothing, P\} \in U \qquad \text{(Eq. 5)}$$

and the Universe Set is, along with the empty set, a subset of the Null Set:

$$\{\varnothing, U\} \in \mathfrak{N} \iff \forall p \forall x \left[U\big(P(0)\big) \wedge \big\{P(0) \iff \langle O, t\rangle\big\} \wedge \left\{p, x^0, x^1, x^2, x^3, x^4\right\}\right] \qquad \text{(Eq. 6)}$$

In this view the universe is fundamentally a set which subsists ontologically in a Leibnizian 'idea realm,' a Platonic realm of Forms, or a divine mind of God, even while the universe itself may have no physical existence. Conversely, consider the universe that exists as a non-null state: the world is then simply U composed of the empty set and all the points and instances within the universe, where at least one of which must have a non-zero value.

The Null Set then becomes Leibniz's mind of God and all possible worlds *subsist* as yet to be populated (non-zero) elements of the Null Set. Symbolically, this yields an interesting result:

$$\exists x\{[\,(x \in \mathfrak{N}) \wedge (x = 0)\,] \implies \Diamond x\} \qquad \text{(Eq. 7)}$$

Understanding that for some x to possibly be the case in some possible world it must be an element of the Null Set, then it is also true that

$$\Diamond x \implies \{x \in \mathfrak{N}\} \qquad \text{(Eq. 8)}$$

However, for x to be a possibility, it is precluded from being also an actuality and so also requires that the value of x is 0. When this is requirement is included in the consequent of equation 8, equation 7 then becomes bi-conditional and we obtain:

$$\exists x\{[\,(x \in \mathfrak{N}) \wedge (x = 0)\,] \iff \Diamond x\} \qquad \text{(Eq. 9)}$$

which of course then equates *possible existence* with *subsistence*! With this equivalence, we are able to liken the Null Set to Leibniz's mind of God and align the elements of the Null set with Leibniz's possible worlds.

<u>The Modality of the Null Universe Hypothesis as Leibniz's Possible Worlds</u>

As the Leibnizian mind of God is the logic-space in which the Null Universe subsists, Leibniz's possible worlds can be modeled as the possible values which can populate Universe Set, U, as a subset of the Null Set, $\mathfrak{N}$. For Leibniz the possible worlds all subsist in the mind of God and God chooses which possible world to create. In the Null Universe hypothesis this same phenomenon is preserved during the initial state of the universe when the Null Set, $\mathfrak{N}$, contains only values of zero. As God (or whatever other mechanism yet to be discovered) chooses which possible world to create, the values of $\mathfrak{N}$ are then populated with non-zero values, and the Universe Set, *U*, begins to emerge with some non-zero value.

While the universe today is of course populated by non-zero values of set *P*, in the era prior to "the Beginning" the universe would have merely subsisted in a null state with exclusively zero-valued subsets. During this aeon the values of set *P* would subsist in a state of timeless (since the time coordinate, x^0, must also have a 0 value) potentiality and so to say something subsists is also to say that it is in *an ontological state of potential*, or that it is in a

state of *possibly* becoming instantiated fact in the world. Similarly, to say *x* exists is to say that it is in *a state of actuality*, or *necessarily* being instantiated fact in world. Therefore, when we speak of necessity and possibility we are in fact speaking about existence and subsistence, or 'being in the universe' and 'being in the mind of God.' This is an important feature of this set-theoretic cosmology because it yields a very interesting and strong modal system, which was also endorsed by Leibniz.

By definition, the logic-space contains all possible relations. So if that logic-space must necessarily exist, then so do all the possible relations. Since God (or more exactly, the mind of God) is that logic-space, and as Leibniz concludes, "God alone has this prerogative that He must necessarily exist, if He is possible,"[48] then it would follow that all possible relations necessarily subsist in the mind of God. Now, recall our definition of subsistence: *that which subsists is in an ontological state of potential fundamental to existence*. This equates subsistence in the mind of God with possibly being the case. If subsistence is itself possibility, then the claim that 'possible relations necessarily subsist' becomes a modal axiom: if p is a possible relation, then it is necessarily the case that p subsists:

$$\Diamond p \longrightarrow \Box \Diamond p \qquad \text{(Eq. 8)}$$

which is the modal **5** axiom from which we derive **S5** modal logic. In other ontologies this logic raises serious concerns about possibility in this world ultimately entails necessity in all worlds. The **4** and **5** axioms,

$$\textbf{4}: \ \Box p \longrightarrow \Box \Box p$$
$$\textbf{5}: \ \Diamond p \longrightarrow \Box \Diamond p,$$

dictate that the modal properties of propositions in this world are irrelevant when discerning modal properties in all possible worlds. In **S5** modal logic "strings containing both boxes and diamonds are equivalent to the last operator in the string"[49] and so the possibility that p is necessary "is the same as saying that p is necessary."[50] From this conclusion we encounter what's known as the modal collapse — namely, that regardless of the antecedent's modality in this possible world we find that the same modality is the case in all possible worlds. However,

[48] Leibniz et al., 1898b
[49] Garson, 2023
[50] Garson, 2023

framing **S5** in this logic-space we have a system wherein the result of these axioms does make sense. We can rephrase (Eq. 8) so that to say "*p* exists" is to say "the information about *p's* state is necessarily the case, if the information about *p's* state's necessary existence subsists." Or symbolically:

$$\Diamond \Box p \longrightarrow \Box p \qquad \text{(Eq. 9)}$$

Importantly, Leibniz had also adopted this axiom in his ontological argument. But while Leibniz upheld the possible existence entailing the necessary existence only of God, this set-theoretic approach suggests that the existence of anything is predicated on its possibly existing. Leibniz writes that with this theorem "existence belongs to its concept or essence"[51] and goes so far as to say that this very theorem is "the pinnacle of modal theory and by which one moves in a wonderful way from potentiality to act."[52] Just as Leibniz required a sort of 'idea space' in which there exist ideals, and by which he produces "in modern parlance, a modal argument for the existence of God,"[53] so too does this Null Universe hypothesis maintain an ontologically real 'logic-space' in which the modal **5** axiom can be sensibly interpreted (and possibly even provide a proof of God[54,55] — although that is a topic for a future essay) to provide a modal argument for the existence of a God-like logic-space.

This modal construction is important because it provides a logical connection between possibly existent things and actually existing things. Whereas Leibniz has possible worlds subsisting in the mind of God, the Null Universe hypothesis has possible worlds subsisting in a logic-space. This modal construction provides a set-theoretic interpretation of a 17th century philosophy, and an ontological framework in which *creatio ex nihilo* can be maintained in a modern cosmological paradigm.

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[51] Antognazza, 2018
[52] Antognazza, 2018
[53] Antognazza, 2018
[54] Bischoff, 2022
[55] Kovač, 2012

Conclusion: Creatio Ex Nihilo as the Null Universe Hypothesis

Earlier it was argued that the *creatio ex nihilo* doctrine can be understood to assert that *the universe was formed by God out of some sort of transcendent a priori logic-space, which is God Himself*. By maintaining a critical distinction between the *absence of matter* and the *absence of reality*, the doctrine of *creatio ex nihilo* is preserved by a real but non-physical logic-space, or 'mind of God,' in which possible elements of the universe can subsist, and from which elements of the universe can be actualized. Presenting the universe and all other possible worlds as elements of a mathematical set then enables the development of an ultimate explanation of things predicated on this eternally subsisting logic-space, and the allowance of possible worlds in that logic-space. We find that this set-theoretic interpretation of the *creatio ex nihilo* doctrine (the Null Universe Hypothesis), as an ultimate explanation of the universe, is Leibnizian and indeed supports the claim that the universe comprises "a certain realm of ideas."[56]

Moreover, the Null Universe Hypothesis provides a mathematical response to as O'Connor's need for some sort of metaphysic, arguing that the universe, prior to its obtaining physicality, subsisted eternally as the Null Set in a logic-space which the theist may call the mind of God. This Null Set contains all possible states of the universe and its elements (i.e. all possible worlds), but with all values equal to 0. As some of these elements and the relations between them obtain a non-zero value, a certain (once merely possible) world is actualized and the universe becomes instantiated as a physical thing with physical elements and relations, from which the laws of nature are allowed to emerge and order future relations. The Null Universe Hypothesis reinterprets the Leibnizian concept of 'the mind of God thinking eternal truths' as 'a mathematical set with an ontological reality in which the mathematical parameters required to define physicality of matter subsist in a logic-space.' This allows us to understand the creation and ultimate origin of the universe as more like a mathematical set being populated, rather than as having all matter and energy simply emerge from some sort of otherwise inexplicable Big Bang. As there is no matter or physicality of the Null Set, the *creatio ex nihilo* paradigm regains meaning as creation from a state of nullity, rather than as creation from the absence of all reality.

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[56] Leibniz et al., 1989

Tacit in the Null Universe Hypothesis however, is not only the equivalence of the logic-space with the mind of God, but also the reality of some non-physical mechanism "by which one moves in a wonderful way from potentiality to act"[57] — which the theist can argue is the reality of a creative deity. If God does indeed exist as the necessary being for which Leibniz argued, then the Null Universe Hypothesis would require that God's Creation is fundamentally mathematical and that God creates *ex nihilo* by thinking the elements of the Universe Set, *U*, which contains all the parameters and eternal truths required to govern the laws of nature and the things subordinate to them. Therefore, the Null Universe Hypothesis posits a refreshed interpretation of the principle of *creatio ex nihilo* as creation by emergence out of a state which, although *physically* identical to 'nothing,' contains all the possible relations and entities which would come to define the physical universe ordered by a Creator.

[57] Antognazza, 2018

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