A New Kalam Argument

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Abstract

Modifying Benardete's Grim Reaper paradox results in a new version of the Kalam cosmological argument: an argument for the necessary finitude of the past. The argument relies upon two crucial assumptions: the intrinsicality of causal powers, and a generalization of Lewis's Patchwork Principle. I distinguish two different senses in which the past might be finite and consider their logical relations. Finally, I argue that the argument's conclusion is consistent with the potential infinite divisibility of time, and that it provides support for the hypothesis that the universe has an extra-temporal and immaterial cause.

1. Introduction

The tradition of the Kalam cosmological argument has fomented controversy for over a thousand years. The argument originates with philosophers of late antiquity and the Middle Ages in the Middle East, beginning with John Philoponus and Al-Kindi, and William Lane Craig has revived and defended the argument (Craig 1979, 1980, 1997, Craig and Sinclair 2009). The Kalam argument is an attempt to establish the existence of a first cause by first demonstrating that time itself had a beginning. Kalam defenders

appeal to the causal principle that everything that begins to exist had a cause of its existence.

There are a variety of ways to argue for the beginning of time. Some arguments attempt to establish the impossibility of an infinite cardinal number of concrete objects, via paradoxes like the Hilbert hotel. Others appeal to supplemental causal principles or to the principle of sufficient reason. In this paper, I provide a new way of arguing for the beginning of time, building on Benardete's Grim Reaper paradox and appealing to a version of David Lewis's 'patchwork principles' of modal metaphysics.

2. The Benardete Grim Reaper Paradox

Alexander Pruss (Pruss 2009) has deployed the Grim Reaper paradox (Benardete 1964, Hawthorne 2000) as an argument for the discrete character of time. In Benardete's paradox, we are to suppose that there is an infinite number of Grim Reaper mechanisms, each of which is engineered to do two things: first, to check whether the victim, Fred, is still alive at the Grim Reaper's appointed time, and, second, if he is still alive, to kill him instantaneously. The last Grim Reaper (Reaper 1) performs this dual task at exactly one minute after noon. The next-to-last Reaper, Reaper 2, is appointed to perform the task at exactly one-half minute after noon. In general, each Reaper number n is assigned the moment $\frac{1}{n}$ minute after noon. There is no first Reaper: for each Reaper n, there are infinitely many Reapers who are assigned moments of time earlier than Reaper n's appointment.

It is certain that Fred does not survive the ordeal. In order to survive the whole ordeal, he must still be alive at one minute after twelve, but, we have stipulated that, if he survives until 12:01 p.m., then Reaper 1 will kill him. We can also prove that Fred will not survive until 12:01, since in order to do so, he must be alive at 30 seconds after 12, in which case Reaper 2 will have killed him. In the same way, we can prove that Fred cannot survive until $\frac{1}{n}$ minutes after 12, for every n. Thus, no Grim Reaper can have the opportunity to kill Fred. Thus, it is impossible that Fred survive, and also impossible that any Reaper kill him! However, it seems also to be impossible for Fred to die with certainty and yet without any cause.

Let us try to be more explicit about the premises needed to generate the paradox. First of all, we must assume that a single, isolated Grim Reaper scenario is metaphysically possible:

P1. Possible Grim Reaper (PGR). There is a possible world W and a region R^1 such that R has a finite temporal duration, there is a Grim Reaper wholly contained within R, and throughout R the Grim Reaper has the power and disposition to kill Fred if Fred is alive at the beginning of R, and otherwise to do nothing.

Secondly, we appeal to some version of David Lewis's Patchwork Principles (Lewis 1983, 76-7). Almost all of our knowledge of possibility is based on patchwork principles, since we have no direct access to alternative possibilities. Instead, we have to rely on our

direct knowledge of the actual world, as well as the license to cut-and-paste or recombine various regions of the actual world into a new arrangement.

Binary Patchwork. If possible world W_1 includes spatiotemporal region R_1, possible world W_2 includes region R_2, and possible world W_3 includes R_3, and R_1 and R_2 can be mapped onto non-overlapping parts of R_3 ($R_{3.1}$ and $R_{3.2}$) while preserving all the metrical and topological properties of the three regions, then there is a world W_4 and region R_4 such that R_3 and R_4 are isomorphic, the part of W_4 within $R_{4.1}$ exactly resembles the part of W_1 within R_1, and the part of W_4 within $R_{4.2}$ exactly resembles the part of W_2 within R_2.

Binary Patchwork licenses recombining region R_1 from world W_1 with region R_2 from world W_2 in any way that respects the metrical and topological properties of the two regions, so long as there is enough 'room' in spacetime as a whole to fit the two regions in non-overlapping locations (as witnessed by the two regions $R_{3.1}$ and $R_{3.2}$ in world W_2). The Binary Patchwork principle can plausibly be generalized to the case of infinitary recombinations:

P2. Infinitary Patchwork (PInf). If S is a countable series of possible worlds, and T a series of regions within those worlds such that T_i is part of W_i (for each i), and f is a function from T into the set of spatiotemporal regions of world W such that no two values of f overlap, then there is a possible world W' and an isomorphism f' from the spatiotemporal regions of W to the spatiotemporal regions of W' such that the part of

each world W_i within the region R_i exactly resembles the part of W' within region $f'(f(R_i))$.

In order to apply the Patchwork principles to Benardete's story, we must assume that the relevant powers and dispositions are intrinsic to the things that have them when they have them. Otherwise, we cannot assume that the joint possibility of an infinite number of Grim Reaper scenarios follows from the possibility of a single scenario, taken in isolation.

P3. Intrinsicality of Powers and Dispositions (PDIn). A proposition P is intrinsic to spatiotemporal region R if P consists of a finite conjunction of atomic propositions ascribing simple powers and dispositions to things located entirely within R at times wholly within R.

We also need to assume that the processes described in the Grim Reaper paradox are, in principle, arbitrarily compressible in space and time. This involves assuming that there is no metaphysically necessary intrinsic scale to spacetime.

P4. Compressibility of Spacetime (CompST). If a proposition P is true in world W and intrinsic to a region R with a finite temporal duration, then there is a counterpart P' of P true in a world W' and intrinsic to a region R' and an isomorphism f from part of R to parts of R' that preserves the topological properties of R, and such that, for each sub-

region S of R, f(S) has exactly one-half the temporal duration and one-half the length of S in every spatial dimension.

If P4 were false, this would have to be because of some essential, intrinsic feature of spacetime, such as granularity, which would itself be inconsistent with the hypothesis of infinitely dense time. Thus, if we suppose that time is dense, then it is reasonable to assume infinite compressibility. Finally, we need to state the hypothesis for the reductio:

H1. Possibility of Bounded and Non-Well-Founded Time Sequence. (BNWF) There is a possible world W and a spatiotemporal region R in W such that (i) there is a time t within R and a finite temporal interval d such that no part of R begins earlier than d before t, and (ii) R has infinitely many temporally extended parts such that these parts can be put into a sequence (ordered by the natural numbers) in which each successive part in the sequence is wholly earlier in time than its predecessor.

Let's compare this hypothesis with some similar propositions:

H2. Possible Density of Time (PDT). There is a possible world W and a region R of W such that R has only a finite temporal extent, and R has infinitely many temporally extended parts such that no two of these parts overlap in time.

H3. Possibility of Bounded and Non-Well-Capped Time Sequence. (BNWC) There is a possible world W and a spatiotemporal region R in W such that (i) there is a time t

within R and a finite temporal interval d such that no part of R ends later than d after t, (ii) R has infinitely many temporally extended parts such that these parts can be put into a sequence (ordered by the natural numbers) in which each successive part in the sequence is wholly later in time than its predecessor.

H1 and H3 both entail H2, but H2 entails neither of them. We can prove that H2 is equivalent to the disjunction of H1 and H3.

Lemma 1. The Possible Density of Time (H2.PDT) entails the disjunction of H1.BNWF and H2.BNWC, i.e., the possibility of either a non-well-founded or non-well-capped sequence, given the standard axioms of mereology.

Proof of Lemma 1. See Appendix.

H4. Symmetry of Temporal Structure (STS). If world W contains region R, then there is a world W' and region R' and an isomorphism f from R to R' that preserves all of the metrical and topological features of R, and such that for all S_1 and S_2 in R, $f(S_1)$ is wholly earlier than $f(S_2)$ if and only if S_2 is wholly earlier than S_1.

Lemma 2. If Symmetry of Temporal Structure (H4.STS) is true, then a bounded and non-well-founded time series is possible if and only if a bounded and non-well-capped time series is possible (H.BNWF if and only if H2.BNWC).

Lemma 3. The Symmetry of Temporal Structure (P5.STS) and the impossibility of bounded and non-well-founded time series (negation of H1.NNWF) entail the impossibility of dense time (Negation of H2.PDT).

However, as we shall see, the Grim Reaper paradox itself gives us reason to doubt H4, the symmetry of temporal structure, since there is no time-reversed counterpart to the paradox (see section 6).

3. From Grim Reaper to Grim Mover

The original Grim Reaper paradox requires some assumption about causality: that Fred cannot die unless someone or something kills him. I would like to eliminate that dependency. Consider the following variation: the Grim Mover. The 'victim' Fred is a point-particle, which begins located on a plane P. Each Grim Mover n checks to see if Fred is already at a distance of $\frac{d}{2^i}$ from plane P, for some i > n: that is, he checks to see if any earlier Mover has already moved Fred. If he has already been moved, then the Grim Mover keeps Fred at that location. If Fred occupies any other position, including any location on plane P, then the Grim Mover n moves Fred to a position exactly $\frac{d}{2^n}$ meters from P. We can now prove both that at 12:01 Fred is not on the plane (since he would have had to 'survive' an infinite number of Grim Movers), and that Fred cannot be any finite distance off the plane. Suppose Fred is some finite distance e from the plane at 12:01. There are two cases: (i) $e = \frac{d}{2^n}$ for some n, and (ii) $e \neq \frac{d}{2^n}$, for all n.

Case (i) is impossible, since if e = $\frac{d}{2^n}$ for some n, then it had to be moved there by Grim Mover n, since any earlier Mover would have moved it to a different location, and any later Mover would have kept Fred at distance e without moving him. In order for Mover n to have moved Fred to distance e, Fred must have been on the plane or off the prescribed path at 12 + $\frac{1}{2^n}$. However, this would have been impossible, since to remain on plane P or otherwise off the path until that time would have required the misfiring of an infinite number of earlier Movers. Case (ii) is similarly impossible, since Mover #1 would have moved Fred to position $\frac{d}{2}$ at 12:00:30.

P1*. Possible Grim Mover (PGM). There is a possible world W and a region R such that R has a finite temporal duration d seconds, there is a Grim Mover wholly contained within R, and throughout R the Grim Mover has the power and disposition to move Fred to a designated position d meters from the plane P if Fred is on the plane P at the beginning of R, and otherwise to do nothing, and Fred has the disposition to remain where he was at the beginning of R, if not moved.

Here's an initially plausible challenge to the possibility of the Grim Mover scenario: is it really possible for the Mover to tell whether the particle is exactly on the plane? If the particle is very, very close to the plane, mightn't the Mover be unable to tell? We can easily fill this gap by changing the story slightly: there is no particle on the plane initially. Instead, each Mover is disposed to move a particle from a considerable distance to that Mover's designated spot. Even though each Mover may not be able to detect the exact

location of the particle, it would still be able to tell whether any earlier Mover has moved the particle to its designated spot.

This last variation requires the early Movers to be able to move the particle with arbitrarily high velocity, since each has to be able move the particle a fixed distance in arbitrarily short period of time. We might be able to eliminate this supposition as well: suppose that the particle does begin on the plane P, and that it interacts there with some field in such a way that were it moved off the plane any distance whatsoever, the displacement would cause some grossly observable alteration in the particle.

Here is the formal argument:

1. Start with a possible Grim Mover in world W and region R, with finite duration d_0. (From P1* Possibility of Grim Mover)
2. Next, locate a world W' with a region R' containing a non-well-founded infinite series of non-overlapping temporal parts. (Assumption of H1.BNWS, for reductio)
3. For each number n, locate a possible world W_n and region R_n, with duration $\frac{d_0}{2^n}$, containing a counterpart of the Grim Mover. (From 1, P2 Intrinsicality of Powers, and P3 Possible Compressibility of Spacetime)
4. Find a single possible world W* with region R* containing a non-well-founded infinite series of non-overlapping temporal parts (R0, R1, etc.), with each R_i containing a counterpart of the Grim Mover. (From 3, 4, and P1 Infinitary Patchwork)

5. In world W*, at the end of each period R_i, Fred is located some distance $\frac{d_0}{2^j}$ from the plane P, for some $j \geq i$. (From P1*)
6. In world W*, at the end of each period R_i, if Fred is located at distance $\frac{d_0}{2^i}$, then at the end of period $R_{(i+1)}$, Fred was not located at distance $\frac{d_0}{2^j}$ for any $j > i$. (From P1*)
7. In world W*, at the end of period R_0, Fred is located some distance $\frac{d_0}{2^n}$, for some n. (Instantiation of 5, replacing 'i' by 0)
8. So, at the end of period $R_{(n+1)}$, Fred was not located at distance $\frac{d_0}{2^j}$, for any $j > n$. (From 6, 7)
9. But, at the end of period $R_{(n+1)}$, Fred was located at distance $\frac{d_0}{2^j}$, for some $j > n$. (Instantiation of 5, replacing 'i' by 'n+1') Contradiction.
10. So, there is no possible world containing a non-well-founded infinite series of non-overlapping temporal parts. (Negation of H1.BNWS)
11. Consequently, if temporal structure is symmetrical, then it is impossible for time to be dense. (From 10 and H4.STS, by Lemma 3)

4. From Grim Mover to the Kalam Argument

In fact, as Alexander Pruss has observed (Pruss 2009), the Grim Reaper paradox suggests not only that no finite time period can be divided into infinitely many sub-periods but also that it is impossible that there should exist infinitely many time periods, all of which are earlier than some event. It seems to provide grounds for thinking that time must be bounded at the beginning: that there must be a first period of time. If not, we could

simply construct the Grim Reaper paradox by supposing that Fred (or his corpse) has always existed, and that a Grim Reaper mechanism is set up to kill him at each period of time in the past. Again, we would be forced to conclude that Fred has been killed at some time in the past, even though there is no moment of time at which he died, and no Grim Reaper mechanism responsible for killing him. For the Grim Mover version, we could postulate the possibility of a Grim Placer, who creates a particle and places it at a designated spot, if and only if no particle is already located at a spot corresponding to any earlier Placer.

We can reconstruct the argument, assuming H5 -- Possible Infinite Past with Infinitely Many Parts -- as the hypothesis for reductio. This argument proves the negation of H5, namely, that the past is necessarily finite in its number of parts:

H5. Possible Infinite Past, with Infinitely Many Parts (PIPIP). There is a possible world W and a region R and time t of W such R has a temporal part wholly earlier than d units before t, for every finite interval d.

H6. Possible Quantitatively Infinite Past (PQIP). There is a possible world W, and a region R and time t of W such that R is wholly earlier than t, and R has infinite duration.

We must distinguish H5 from H6, Possible Quantitatively Infinite Past. H6 is entailed by H5 (given standard mereology) but it does not seem to entail H5, since H6 is compatible with there being a set of earliest spacetime regions of infinite duration but with no proper

parts. We could call this a simple infinite past. The Grim Placer argument does not establish the impossibility of such a simple infinite past.

H6 would entail H5, however, if such a simple infinite past were impossible. Consider hypothesis H7:

H7. No Simple Infinite Past. No spacetime region can have an infinite duration without having infinitely many proper parts or overlapping an infinite series of temporally finite and temporally disjoint regions.

For it to be possible for a simple region to have measurable temporal duration without parts, the simple region would have to either contain a process with a natural beginning and end or temporally overlap with one or more such processes. Thus, we can reasonably embrace the possibility of simple regions with *finite* duration, a duration corresponding to the natural distance between the two endpoints in processes of this kind. However, a simple region with an *infinite* duration in the past would have to contain only processes without a natural beginning, and we might well ask how any such process could have a temporal measure, without having proper parts or overlapping in time with other regions. Time is the measure of change, which seems to require both a terminus a quo and a terminus ad quem. This assumes, of course, that time has no intrinsic metric of its own.

Here's another argument for H7. A simple region can have a temporal measure only if it is potentially divisible into parts. A region is divisible into temporal parts only if it

contains one or more processes that can potentially be stopped or interrupted. A process P is potentially stoppable only under certain conditions:

(i) P itself has a natural, finite measure, based on the normal distance in time between its terminus a quo and terminus ad quem, a measure that can be shortened by accelerating P.

(ii) There is another process P' which, when it reaches its terminus ad quem, has the power of terminating P, and P' is stoppable before the termination of P.

However, if the early history of the world consists entirely of processes without finite measures, then none of those processes is potentially stoppable, and hence none of the spatiotemporal regions containing them is even potentially divisible in the temporal dimension. Regions that contain no temporal parts at all (actual or potential) and that temporally overlap only other regions without temporal parts cannot have a temporal measure. Hence, a mereologically finite past must be a quantitatively finite past.

5. Objections

5.1 Dispositions Need not be Intrinsic

Jennifer McKitrick[1] has argued that, contrary to P3 (The Intrinsicality of Powers and Dispositions), many dispositions are not intrinsic to their bearers. For example, weight is

[1] Jennifer McKitrick, "A case for extrinsic dispositions," *Australasian Journal of Philosophy* 81(2007):155-74.

a disposition that depends upon the strength of the ambient gravitational field. However, the argument does not require the full strength of P3. Even if McKitrick is right about some dispositions, all that we need to assume is that the powers and dispositions that are definitive of the Grim Reaper (and Mover and Placer) scenarios are intrinsic to those situations, which is clearly the case.

5.2 Dispositions and Powers can Fail

In the argument for the contradiction, I assumed that all of Grim Reapers are effective at exercising the specified powers. However, causal powers may fail, and a thing may act on occasion, in a way contrary to its dispositions.

This objection fails, since the argument does not require the assumption that powers are always or necessarily exercised successfully: only that it is possible for a power to be exercised successfully. Let's assume that whether or not a power is exercised successfully, and whether nor not some disposition is followed in exercising it, is a matter intrinsic to the situation in which the exercise occurs. If so, we can assume the P2, the Infinitary Patchwork principle, applies to the multiplication and arrangement of an infinity of *successfully executed* Grim Reaper scenarios.

5.3 Neo-Humeanism

The argument does not depend on assuming that all powers and dispositions are intrinsic, but it does depend on assuming that some are. On a Neo-Humean account of causal powers (as advocated by David Lewis and Theodore Sider – Lewis 1986 and Sider 2000), any power or disposition that anything has depends on the pattern of events involving similar things across the history of the world. If this neo-Humean account is right, then the Patchwork Principle does not apply to scenarios specified in terms of causal powers or dispositions.

However, the very fact that neo-Humeanism entails the extrinsicality of powers and dispositions provides compelling grounds for rejecting it. The neo-Humean account gets the order of explanation between powers and their manifestations wrong, making the possession of powers dependent on the pattern of manifestations. Any modification of the neo-Humean account that avoids this consequence would be compatible with the intrinsicality of the relevant powers and dispositions, and the applicability of Patchwork to the Grim Reaper scenarios.

5.4 Spacetime is Necessarily Discrete (Granular)

One might try to resist the argument by challenging P4, the Infinite Compressibility of Spacetime. The Grim Placer requires an infinite series of locations, approaching arbitrarily close to the plane P. We might try to avoid this assumption by spacing the locations an equal distance apart, eliminating the plane P and instead allowing the designated locations to stretch infinitely far into space. However, doing this would

require each successive Placer to check a potentially infinite number of locations to see if a particle is already located there. This would require a signal that accelerates without limit, in such a way that the Placer can expect an 'echo' signal's return within a finite period of time, no matter how far away an answering particle might be.

To block the argument, then, we would have to suppose two things to be true:

(A) There is a finite distance d and a finite duration t such that no spatiotemporal region in any possible world has a length less than d or duration less than t.
(B) There is a velocity v such that no signal or causal influence in any possible world travels in that world at a velocity greater than v.

To show that either the past is necessarily finite or that both (A) and (B) are true is quite a significant metaphysical result. In addition, there are clear reasons to prefer the necessary finitude of the past to the conjunction of (A) and (B). First, modern physics assumes that (A) is false by using the mathematics of the continuum in describing the physical world. Second, (A) is inconsistent with special relativity, since it entails that there is an absolute measurement of both distance and time (in terms of the cardinal number of the metaphysically minimal units). Finally, the falsity of (A) and (B) seem to be clearly conceivable, while the intelligibility of an infinite past is much more problematic.

6. Is Endless Time Impossible?

Can the Grim Placer argument establish the existence of an end to time, as well as a beginning? Consider the three future-oriented counterparts to hypotheses H1 and H5:

H3. Possibility of Bounded and Non-Well-Capped Time Series. (BNWC) There is a possible world W and a spatiotemporal region R in W such that (i) there is a time t within R and a finite temporal interval d such that no part of R ends later than d after t, (ii) R has infinitely many temporally extended parts such that these parts can be put into an omega-series in which each successive part in the series is wholly later in time than its predecessor.

H8. Possible Infinite Future, with Infinitely Many Parts (PIFIP). There is a possible world W and a region R and time t of W such R has a temporal part wholly later than d units after t, for every finite interval d.

Can we also show that time is bounded in the future: that there will be a last period of time (the denial of H8)? Or even that every region has a final part (the denial of H3)? Apparently not. The only way to construct the Grim Reaper paradox in reverse would be to stipulate that each Reaper is able to check whether or not Fred will be alive at the end of his appointed period, and to kill him if he will, which doesn't make any sense. The apparent connections between time, knowledge and action all seem to rule out the

possibility of such a paradox, without providing any grounds for rejecting hypotheses concerning the endlessness of time.

If we try to avoid such impossibly forward-looking dispositions, then we would be unable to say how the Grim Reaper is to respond to finding Fred alive at the beginning of his period (since this would correspond to Fred's being alive at the end of the period in the original paradox, which is stipulated to be impossible). Similarly, we cannot say when a Grim Reaper is to 'kill' a dead Fred, since the Reaper is supposed to kill him if and only if he becomes alive at the end of his period. Thus, there is no plausible future-oriented version of the P1, the Possibility of the Grim Reaper.

7. The Upshot of the Argument

7.1 The Discreteness of Time

Does the paradox give us reason to believe that time always consists of a finite number of indivisible 'atoms' of time?

H9 Temporal Discretism. Every finitely long period of time has only finitely many temporal parts (actual or potential).

Let's suppose that we find some reason for rejecting H3 (Non-Well-Capped Series) as well as H1 (Non-Well-Founded Series). For instance, we might take Thomson's Lamp

(Thomson 1954) super-task as impossible, and use that impossibility, along with the impossibility of the Grim Reaper, as grounds for rejecting the possible density of time. Whether the impossibility of temporal density gives us reason to accept Temporal Discretism depends on whether we can make sense of the idea of 'potential but not actual' temporal parts. A spacetime region R in world W has 'potential' temporal parts if and only if R has a counterpart in world W' with actual temporal parts there. I don't see any way to extend the Grim Reaper argument in order to prove that spacetime regions might not have infinitely many potential parts, in this sense. There seems to be room for an Aristotelian position here, according to which time is potential.

7.2 The Existence of God

Suppose that we are convinced that not only H5 but also H6 are false. Suppose, that is, that we are convinced by the arguments in section 4 that H7 (No Simple Infinite Past) is true, and, consequently, that the past is necessarily finite in measure. Would these results have any implications for the existence of God? The most common form of the argument, according to Craig, involves an appeal to some causal principle such as this:

Kalam Causal Principle (KCP): every entity that has a beginning in time has a cause.

The quantitative finitude of the past entails that time itself (or, if you prefer, spacetime) has a beginning. If we suppose that causes and effects are 'separate existences' (as Hume put it), then we can reach the conclusion that there is some extra-temporal entity that it is

the cause of time or spacetime itself, assuming that we are substantivalists about time or spacetime, bringing them within the scope of the KCP.

If we use the term 'the universe' to refer to the totality everything that spacetime contains, we may ask whether there is a cause of the universe. Since the universe has a beginning, we can certainly infer that it has a cause, if it exists. However, we cannot reach this conclusion without assuming something like Mereological Universalism. We need some principle to license the inference to the conclusion that there is some one thing (some entity) that is the sum of all spatiotemporal things.

Alternatively, we could try to use a somewhat stronger Causal Principle:

Strengthened Kalam Causal Principle (SKCP): any entities that jointly have a common beginning in time have some things that cause them (and the latter things are not among the former things).

Very Strong Kalam Causal Principle (VSKCP): any interdependent entities that jointly have a common beginning in time have a single, joint cause.

Either principle would give us the conclusion that the universe has at least one cause, a cause which itself must be extra-temporal and, hence, immaterial.

It is at least arguable that a truly extra-temporal entity would have to be one that exists necessarily, since if a thing's existence is contingent, so it would seem would be its existing at all times rather than at only some times. If a being is only contingently everlasting, then it is not truly extra-temporal: it is still in principle subject to change, even if it is de facto unchanging. If we can show that the universe's cause is a necessary being, then we draw on a treasury of familiar arguments for supposing that cause to be divine. (See, for example, Aquinas's *Summa Contra Gentiles*, or Koons 1997.)

Appendix

Proof of Lemma 1. Suppose that T is dense, but that it contains no non-well-founded or non-well-capped time series.

Let S* be the set of temporally ordered finite or infinite sequences of parts of T: that is, S belongs to S* just in case S is a countable sequence, every constituent of S is a part of T, and for every number i, either S_i begins before S_{i+1}, or S_i ends later than S_{i+1}. There must be at least one infinitely long sequence in S*, because if every member of S* were finite, then there would be a longest member of S* ordered from earliest to latest beginnings, E^+, with length m, and, for each member E^+_i of E^+, a longest member of S* ordered from latest to earliest endings containing only parts of T that begin at the same time as E^+_i, sequence $L^{+(i)}$, with length k_i. We could then construct a finite sequence $S^{\#}$ that contains every part of T, as follows:

$$S^{\#} = < L^{+(0)}{}_{k_0}, L^{+(0)}{}_{k_0-1} \ldots, L^{+(0)}{}_1, L^{+(0)}{}_0, L^{+(1)}{}_{k_1}, L^{+(1)}{}_{k_1-1} \ldots, L^{+(1)}{}_1, L^{+(1)}{}_0, , \ldots, \ldots,$$

$$L^{+(i)}{}_{k_i}, L^{+(i)}{}_{k_i-1}, \ldots, L^{+(i)}{}_1, L^{+(i)}{}_0, \ldots, \ldots, L^{+(m)}{}_{k_m}, L^{+(m)}{}_{k_m-1}, \ldots L^{+(m)}{}_1, L^{+(m)}{}_0 >$$

The sequence $S^{\#}$ is thus built up from a finite chain of finite sub-sequences of S*, and yet $S^{\#}$ exhausts the parts of T, since every part of T is either a member of E^+ or begins at the same time as a member of E^+ (since E^+ is maximal). However, the density of T entails that T has infinitely many parts.

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[1] For the sake of convenience, I will assume that R is a spatiotemporal region, and not merely a span of time. However, we could easily be generalize the argument to the case in which the Grim Reapers are immaterial beings, having temporal but no spatial location.