2

Is the Past Infinite? An Assessment of the Current Literature

2.1 Introduction

Whether the Universe has an ultimate beginning is a question which philosophers and scientists have wrestled with for a long time. Scientists have discovered that there are over 200 billion stars in our galaxy. Even if we could travel at the speed of light—about 300,000 kilometres per second—it would take about 100,000 years to travel from one end of the galaxy to the other. More astounding still is the fact that our galaxy is merely one of the over 100 billion galaxies in existence, many of which have hundreds of millions of stars. And this is merely the currently observable universe; the actual universe is much larger. The Universe is truly awesome.

What ultimately explains the wonder of the night sky? Where do these billions of stars come from? What caused their existence, and what is the cause of the cause(s) of their existence? Could there be an actual infinite regress of causes, and could time be infinite in the past (i.e., could there be an actual infinite temporal regress)? Although the last two questions are distinct, they are related. Given that I define 'time' in terms of changes and 'cause' in terms of producing or bringing about

A.T.E. Loke, *God and Ultimate Origins*, Palgrave Frontiers in Philosophy of Religion,
DOI 10.1007/978-3-319-57547-6_2

something else (which involves producing or bringing about a change; see further, Chap. 3), the impossibility of an actual infinite temporal regress would entail the impossibility of an actual infinite regress of changes and the impossibility of an actual infinite regress of causes. In this chapter, I shall assess the literature related to whether an actual infinite temporal regress is possible.

2.2 The Origin of Our Universe: Big Bang Cosmology

Let us begin with one of the most significant scientific proposals of the twentieth century: the so-called Big Bang theory. In 1917, when Albert Einstein applied his General Theory of Relativity to the cosmos, he realised that our universe is not stable: it is either collapsing or expanding. Refusing to accept this bizarre conclusion, he made an ad hoc insertion of a 'fudge factor' into his equation so that the Universe would appear to be stable. Other scientists (Alexander Friedmann and Georges Lemaître), however, took this problem seriously and separately worked out theorems which show that the Universe is expanding. A confirmation of this finding came in 1929 when the astronomer Edwin Hubble observed the redshifts of galaxies which indicate that the distances between the galaxies are increasing at a tremendous rate. Subsequently, scientists detected the radiation (Cosmic Background Radiation, CBR) which indicates that our universe had a hot, explosive beginning.

It is truly astonishing to think that the billions of stars and galaxies of our universe came from this explosion. Cosmologist George Ellis summarises the evidences for this conclusion:

> Observational support for the idea of expansion from a Hot Big Bang epoch is very strong, the linear magnitude- redshift relation for galaxies demonstrating the expansion, with source number counts and the existence of the blackbody CBR being strong evidence that there was indeed evolution from a hot early stage. Agreement between measured light element abundances and the theory of nucleosynthesis in the early universe

> confirms this interpretation…Thus the present dominant cosmological paradigm is a quantum gravity era of some kind followed by inflation; a Hot Big Bang epoch; decoupling of matter and radiation; and then gravitational instability leading to formation of clusters of galaxies. (Ellis 2007, Sect. 2.8)

Because of the abovementioned evidences, the vast majority of scientists today agree that our universe had an explosive beginning (although controversies concerning certain details of this explosion remain, see below). Some have even drawn theistic implications from it, and regarded it as the process by which God created the Universe. For example, astronomer Arno Penzias, who won the Nobel Prize in 1978 for the discovery of Cosmic Background Radiation, confesses that his investigation of astronomy has led him to see 'evidence of a plan of divine creation'. He states that 'the best data we have are exactly what I would have predicted, had I had nothing to go on but the five books of Moses, the Psalms, the Bible as a whole' (Browne 1978). Robert Jastrow, the former chief of the Theoretical Division of NASA (1958–1961), likewise expresses his astonishment with these words

> The instant of the explosion marked the birth of the Universe… It was literally the moment of Creation… The scientist's pursuit of the past ends in the moment of creation. This is an exceedingly strange development, unexpected by all but the theologians. They have always accepted the word of the Bible: in the beginning God created heaven and earth. (Jastrow 2000, pp. 106–107)

2.3 Does Big Bang Cosmology Disconfirm Theism?

On the other hand, philosopher Hans Halvorson observes that a vocal minority of philosophers, such as Adolf Grünbaum and Quentin Smith, have claimed that Big Bang cosmology disconfirms theism. They argue that the so-called 'Standard Version' of the Big Bang (also known as the

Friedmann–Lemaître–Robertson–Walker [FLRW] model) has no first state at which God could have created the Universe. They also argue that it makes no sense to claim that the Universe was caused given that there was no time before the Big Bang (since, according to the FLRW model, time itself came into existence with the Universe) (Halvorsen 2011).

We shall now consider these two arguments in detail.

(1) On the first argument, Grünbaum objects to Craig's (1994, pp. 218, 222n.1) idea that the Big Bang singularity and its purported divine cause 'both occur coincidentally (in the literal sense of the word), that is, they both occur at t_0.' Grünbaum (1994) argues that 'only *events* can qualify as the momentary *effects* of other events, or of the action of an agency. *Since the Big Bang singularity is technically a non-event, and* $t = 0$ *is not a bona fide time of its occurrence, the singularity cannot be the effect of any cause*.' Grünbaum explains

> Points of the *theoretical* manifold first *acquire* the physical significance of being *events*, when they stand in the chrono-geometric relations specified by the space-time metric, which does double duty as the gravitational field in the GTR [General Theory of Relativity]. Thus, in the GTR, it turns out that 'the notion of an event makes physical sense only when [both] manifold and metric structures are [well] defined around it' … And in that theory, space-time is taken to be 'the collection of all [physical] events' … *Thus, the Big Bang does NOT qualify as a physical point-event of the space-time to which one would assign three spatial coordinates, and one time coordinate*. Therefore… the past cosmic time-interval is *open* or unbounded at $t = 0$, rather than closed or bounded by a first moment. (Grünbaum 1994)

Grünbaum (1989) postulates that the objects in the Universe could have come from an infinitude of prior transformations from matter or energy existing earlier in other forms *during an unbounded past*.

In reply to Grünbaum, it should be noted that, on the one hand, Grünbaum's conclusions concerning the beginning of our universe are unwarranted, given that the known laws of physics break down at that initial state. As cosmologist William Stoeger explains:

> Using a simple physical-mathematical model of such a universe, the Friedmann–Lemaître–Robertson–Walker (FLRW) model, we find that at a finite time in the past, such a universe had to be infinitely hot and infinitely dense. This is often referred to as the initial singularity or the Big Bang. However, we have already stressed that the physics of space-time that we know – and which is assumed in the FLRW model – breaks down at extremely high temperatures, at about 10^{32} K (the so-called Planck temperature). Above that temperature the universe was enjoying the Planck era. Accordingly, this Big Bang initial singularity given by the FLRW model does not represent what really occurred, and is not the beginning of the universe. It is only the beginning in time according to the FLRW model – but precisely in the region where that model fails. The Big Bang as this initial singularity, then, is an artefact of a model which is very reliable at lower temperatures but far from correct for temperatures above the Planck temperature. Thus, it should be considered only as the past limit of the hotter denser phases of the universe as one goes back into the past – a limit falling outside the reliability of the model, as does the Planck era itself. A new physics is needed, which, as we have already indicated, requires a quantum treatment of space-time and gravity. This is the realm of quantum cosmology. (Stoeger 2010, pp. 175–176)

Stoeger's explanation indicates that, while one cannot assume that there was a first state of the Universe given that the physics of space-time that we know of break down at high temperatures, one cannot be sure that it was unbounded in the way Grünbaum assumed either. The fact that there is no sufficient evidence for such an unbounded beginning has led scientists to propose a variety of alternative cosmological models (such as the Hartle–Hawking model and the Ekyroptic model; see below, Sect. 2.4).

On the other hand, as will be shown in the following sections of this chapter and the next, there are reasons for thinking that an actual infinite regress of changes is metaphysically impossible. This would imply that Grünbaum's postulation that the objects of our universe could have come from an infinitude of prior transformations from matter or energy existing earlier in other forms is metaphysically impossible.

Moreover, there are arguments for the conclusion that the Universe did not begin to exist uncaused which do not require the beginning of universe to be a physical point-event. Rather, these arguments only require that the Universe had a first duration of existence of a certain finite length (see further, Chap. 5). Time can begin even if there is no first extension-less instant. As Smith and Oaklander (1995, p. 10) explain

The hour from 12 noon to 1 o'clock has a first instant that is exactly 12 noon and a last instant that is exactly 1 o'clock. Now delete the instant that is 12 noon. There is still an hour, since if you subtract one instant from the infinite number of instants that compose the hour, you still have an infinite number of instants and one hour. But this hour has no first instant! Why? Because there is no instant that immediately follows the deleted instant that is 12 noon.

(Note that this explanation grants Grünbaum's assumption that time is composed of instants. I shall argue in Sect. 2.7 that this assumption is problematic.)

As explained in Chap. 5, the definition for 'beginning to exist' used in the argument (modified from Craig's work) is:

x begins to exist at *t* ('*t*' could be instants or moments of non-zero finite duration) iff

i. *x* exists at *t*, and the actual world includes no state of affairs in which *x* exists timelessly,
ii. *t* is either the first time at which *x* exists or is separated from any $t' < t$ at which *x* exists by an interval during which *x* does not exist.

Given that '*t*' could be instants or moments of non-zero finite duration, this definition of 'beginning to exist' works for non-zero moments and intervals of time.

Against philosopher Brian Pitts, who raises the worry concerning the compatibility between the lack of first point of time and the Kalam Argument, Craig and Sinclair (2012, p. 99) reply, 'Pitt's objection presupposes that beginning to exist entails having a beginning point. But why should we think that?' They go on to explain that it has not been proven that space and time are really composed of an actual infinity of points rather than simply modelled as such in General Relativity (ibid., p. 100). They also argue that the idea of *having a beginning point* lands one in the ancient Greek paradoxes of motion, viz., if an object O is at rest at time t, it is impossible for O to begin to move, since if O is in motion at any time t', then there is an earlier time t^* (where $t < t^* < t'$) at which O is already in motion, and hence there is no first time at which O begins to move (!) (ibid.). To reply that t' is the first time at which O is in motion will not do, for t is supposed to be the last point in time at which O is at rest, and one can always think of t^* (where $t < t^* < t'$) for any t or t' (ibid.). They propose that

> Something has a beginning just in case the time during which it has existed is finite. Time itself may be said to begin to exist just in case for any nonzero, finite interval of time that one picks, there are only a finite number of congruent intervals earlier than it. (Craig and Sinclair 2009, pp. 185–186)

Alternatively, 'time begins to exist just in case for some specified nonzero, finite interval of time, there are no congruent intervals earlier than it. In either case beginning to exist does not entail having a beginning point' (ibid.).

Reichenbach (2016) notes that one could also respond to Grünbaum by broadening the notion of 'event' by removing the requirement that it must takes place within a space-time context, i.e., with time prior to it and with space in which it occurs. He observes that, while Grünbaum thinks that there is neither time prior to the Big Bang nor a space in which the Big Bang occurs, nevertheless on this view it is still true to say that at the Big Bang the space-time universe commences. Reichenbach concludes

> One might consider the Big Bang as either the event of the commencing of the universe or else a state in which 'any two points in the observable universe were arbitrarily close together' (Silk 2001, 63). As such, one might inquire why there was this initial state of the universe in the finite past. (ibid.)

(2) We shall now consider the second argument, viz. the argument that, since there was no time before the Universe began, the Universe could not be caused. Grünbaum (1991) explains that it would be wrong to say that the Universe 'came out of' a prior state of nothing on the FLRW model, since there is no 'prior' on this model.

Grünbaum's argument assumes that, if there is a cause of the Universe, then the cause must be temporally prior to the beginning of the Universe. However, there does not seem to be adequate justification for the assumption that a cause must be in such a temporal relation with its effect. As Craig argues, the notion that causes always stand in temporal relations with their effects can be treated 'merely an accidental generalization of our daily experiences, 'akin to Human beings have always lived on the Earth, which was true until 1968. There does not seem to be anything inherently temporal about a causal relationship' (Craig and Sinclair 2009, pp. 188–189). Likewise, Reichenbach (2016) argues that one need not require that causation embody the Human condition of temporal priority, but may treat causation conditionally or as a relation of production.

On the one hand, we must be careful not to beg the question against the possibility of a Timeless Cause, one that is causally but not temporally prior to the Universe. On the other hand, the arguments against something beginning to exist uncaused (see Chap. 5) would hold regardless of whether time exists before the Universe began. This implies that on the FLRW model the Universe would still have a cause, one that is not temporally prior to the Universe.

2.4 A List of Proposed Cosmological Models for Explaining the Big Bang

The upshot of the foregoing discussion is that there is no good reason to think that the FLRW model of the Big Bang disconfirms theism. Nevertheless, there are problems with drawing the theistic conclusion directly from this model as well. As noted earlier, the fact that the physics of space-time that we know break down at the beginning of the Big Bang allows for diverse alternative cosmological models which have been proposed by various cosmologists. While there is no longer any significant doubt that our universe had an explosive beginning about 14 billion years ago, this conclusion does not imply that there was a beginning to all physical things. As Barr explains, our universe is not necessarily the totality of all physical things, but a 'space-time manifold' that possess some well-defined geometrical properties. He notes that over the years a number of speculative cosmological scenarios have been proposed in which the Big Bang was not the beginning (Barr 2012, pp. 179–183). An example of this is the oscillating model. Concerning this model, physicist Steven Weinberg (1977, p. 154) observes: 'Some cosmologists are philosophically attracted to the oscillating model, especially because… it nicely avoids the problem of Genesis.' Nevertheless, there are also other cosmological models (e.g., Vilenkin's) in which there was a beginning to all physical things. As the scientific discipline of cosmology progresses, new cosmological models will continue to be proposed to explain the Big Bang. The following is a list of various types of proposals together with a number of contemporary examples:

Type (1): Originates from a finite past ex nihilo: e.g., Vilenkin's (1982) 'Creation from Nothing' model (see Chap. 5).

Type (2): Originates from Closed Timelike Curves (CTCs) where the Universe 'creates itself', e.g., the model by Gott and Li (see Chap. 4).

Type (3): Originates from a timeless initial state e.g. the Hartle–Hawking no-boundary proposal (see Chap. 6).

Type (4): Originates from an actual infinite temporal regress, e.g.,

- Andrei Linde's (1994) eternal inflation model
- Baum and Frampton (2007) phantom bounce cosmologies
- Veneziano and Gasperini's (2003) 'pre-Big Bang theory' based on analogues of the dualities of string theory
- the 'Ekyroptic universe' initiated by a collision between pre-existing 'branes' in a higher dimensional spacetime (Steinhardt and Turok 2005).

- asymptotically static universe: one in which the average expansion rate of the Universe over its history is equal to zero. 'The inflationary universe emerges from a small static state… The universe has a finite initial size, with a finite amount of inflation occurring over an infinite time in the past' (Ellis and Maartens 2004, p. 223).

There are other proposals, such as the Loop Quantum Gravity model (Bojowald et al. 2004), and Poplawski's (2010) Black Hole model (which proposes that our universe might have originated from a black hole that lies within another universe), which are not committed to whether there is an actual infinite temporal regress (for example, whether that universe was born from a black hole in another universe, which was born from a black hole in another universe, and so on) or a finite past.

A recent paper by Ali and Das (2015) claim to have shown that an actual infinite past is possible, by arguing that the trajectories along which particles travel could have avoided converging at a singularity in the past. However, it should be noted that, even if the trajectories do not converge, this does not prove that the particles which travel on them could have existed forever. Nor does it prove that the trajectories could have extended infinitely in the past, for there could be metaphysical considerations (such as the arguments against an actual infinite past which are discussed below and in Chap. 3) which imply that the non-converging trajectories (if they exist) would have starting points. In his debate with Craig, Sean Carroll cites the Quantum Eternity Theorem (QET) as evidence that the Universe did *not* have a beginning (Carroll and Craig 2014). However, by citing the QET as evidence that the Universe did *not* have a beginning, Carroll bears the burden of proof. In which case he bears the burden to prove that QET is valid at all moments of time. But he has failed to do this (physicist Aaron Wall [2014a] challenges this and other assumptions Carroll made, and notes that Carroll acknowledges that Quantum Gravity is speculative). On the other hand, I would argue that the philosophical arguments against an actual infinite regress of events and against a closed circular loop (see below, Chaps. 3 and 4) would imply that there is an ultimate beginning and that the QET could not have been valid at all moments of time.

Additionally, the abovementioned proposals are beset by the problem that we do not currently have a well-established theory of quantum gravity, without which these proposals are, in the words of Ellis (2007, Sect. 2.7), 'strongly speculative, none being based solidly in well-founded and tested physics, and none being in any serious sense supported by observational evidence. They are all vast extrapolations from the known to the unknown.'

Other problems concerning Type (1) proposals ('Originate from a finite past ex nihilo') will be discussed in Chap. 5, problems concerning Type (2) proposals ('Originate from CTCs') will be discussed in Chap. 4, problems concerning Type (3) proposals ('Originate from a timeless initial state') will be discussed in Chap. 6, and problems concerning Type (4) proposals ('Originate from an actual infinite temporal regress') will be discussed below and in the next chapter.

With regards to Type (4) proposals, on the one hand, Ellis (2007, Sect. 9.3.2) argues that it is not possible for science to prove that the Universe is past infinite; 'observations cannot do so, and the physics required to guarantee this would happen… is untestable.'

On the other hand, many philosophers and physicists of various persuasions (theists, atheists) have argued that cosmological models which attempt to avoid a beginning face various technical difficulties related to the Second Law of Thermodynamics, acausal fine-tuning, or having an unstable or a metastable state with a finite lifetime. Models which attempt to avoid a beginning by postulating a reversal of the arrow of time nevertheless have a type of 'thermodynamic beginning' which still requires an explanation (Craig and Sinclair 2009, pp. 179–182; Bussey 2013; Wall 2014b).

On the basis of the considerations mentioned above as well as others, Craig (2013, pp. 14–15) has concluded that we appear to have strong scientific confirmation of the conclusion that the Universe had an absolute beginning. Morriston objects that Craig is overly optimistic. Morriston argues that what we are really talking about here is just the Universe as far back in time as we can 'see', given currently well-established physical theory, and we could have no reason to conclude that there could not have been an earlier universe operating in accordance with quite different physical laws. (For example, we don't know enough about the so-called 'early' universe to say just how far back the Second Law of Thermodynamics reaches [Morriston 2013, pp. 21–22].) The scientific case which Craig attempts to provide on the basis of currently well-established physical theories is not without significance, however. At the very least, it indicates that his conclusion that there was a beginning to all physical things is not inconsistent with mainstream science. It is noteworthy that an eminent and highly motivated opponent of Craig such as cosmologist Laurence Krauss was willing to agree with Craig in public debate that it is likely that there was such a beginning (Krauss and Craig 2013; Krauss emphasises that we nevertheless cannot know with certainty, while Craig argues that in this case reasonableness of belief does not require certainty but likelihood).

In addition to scientific arguments, Craig has offered two philosophical arguments for concluding that an actual infinite temporal regress is metaphysically impossible. (A metaphysical impossibility is a violation of metaphysical necessity. Noting the distinction between properties which a thing possesses by its very nature and properties that it has merely accidentally, we can say that a proposition is metaphysically necessary just in case it is true in virtue of the natures of things [Fine 1994]. Metaphysical impossibility is more expansive than logical impossibility; for example, it is logically possible but metaphysically impossible for something to be red but not extended [Gendler and Hawthorne 2002, p. 5].)

These two arguments are:

i. The argument for the metaphysical impossibility of concrete infinities: Craig and Sinclair (2009, pp. 103–117) argues that the absurdities which result from paradoxes such as Hilbert's Hotel show that concrete infinities cannot exist, and since an infinite temporal regress of events is a concrete infinity, it follows that an infinite temporal regress of events cannot exist.
ii. The argument for the impossibility of traversing an actual infinite: Craig and Sinclair (2009, p. 117) argues that a collection formed by successive addition cannot be an actual infinite, and the temporal series of events is a collection formed by successive addition, therefore, the temporal series of events cannot be an actual infinite.

These arguments are not susceptible to the abovementioned objection by Morriston, for they attempt to demonstrate certain conclusions about the essential nature of concrete infinities which, if true, are true in all possible worlds. In the rest of this chapter, I shall review the literature on these arguments. Before we discuss these arguments, it is important to clarify what an actual infinite temporal regress means.

2.5 The Idea of Infinite Regress

Let us begin with a brief explication of the key term 'infinite', omitting many details and focusing only on those that are of importance in the context of our present discussion. Here, we need to distinguish between an 'actual infinite' and a 'potential infinite'. An actual infinite is larger than any finite number. Craig utilises the understanding of an actual infinite set as any set that has a proper subset that is equivalent to it. A proper subset is a subset where 'at least one member of the original set is not also a member of the subset.' Two sets are said to be equivalent if the members of one set can be related to the members of the other set in a one-to-one correspondence, that is, so related that a single member of the one set corresponds to a single member of the other set and vice versa. Equivalent sets are regarded as having the same number of members. For example, an original actual infinite set of integers (1, 2, 3, 4, 5, 6…) has a proper subset of even numbers (2, 4, 6…) which has an equivalent number of members as the original actual infinite set (Craig and Sinclair 2009, pp. 103–105). There are two different kinds of actual infinite, countable infinite and uncountable infinite (which is larger than a countable infinite). The number of all whole numbers (…−2, −1, 0, 1, 2…) is a countable infinite known as aleph-zero. The order type of the positive numbers (1, 2, 3…) is ω. The order type of the negative numbers (…−3, −2, −1) is ω^*. An actual infinite is conceived as a determinate whole with an infinite number of members, in contrast with a potential infinite which never attains infinity, although it increases perpetually towards infinity as a limit. At any point in time a potential infinite is actually finite (Craig and Sinclair 2009, pp. 103–105). Craig explains that, because set theory with its definite and distinct elements does not utilise the notion of potential infinity, a set containing a potentially infinite number of members is impossible, indeed no set could capture the essentially dynamic character of potential infinite. Such a collection would be one in which the membership is not definite in number but may be increased without limit. It would best be described as indefinite (ibid.). Against Oppy's tenseless characterisations of potential infinite (Oppy 2006, pp. 261–264; cf. pp. 244–245), Craig observes that a major shortcoming of these characterisations is that they are incapable of handling dynamic views of time which regard tense and temporal becoming as objective features of reality and, hence, worlds in which the future is potentially infinite in the sense of growing toward infinity as a limit (Craig 2008, 201–208). In contrast with aleph-zero, which is a number, ∞ is used for infinity understood as a limit.

When we ask for the causes of the stars, as well as the causes of the causes of their existence, we are asking for causes which actually existed; we are not asking for causes which potentially existed. Likewise, the events that led to the formation of our sun, for example, had already happened, that is, they had already been actualised, and their number is no longer increasing perpetually but a determinate whole. Hence, when we ask whether there could be an infinite regress of causes, events, changes or intervals of time, we are asking whether there could be an actual infinite regress, and not whether there could be potential infinite regress. For given that the number of causes, events, changes or intervals of time in the past of any event is a determinate whole, it cannot be a potential infinite. The past is either actual infinite or actual finite (Craig and Sinclair 2009, p. 115 explains that Aquinas' [*Summa Theologiae* 1.a.7.4] confusion regarding this point allows him to reject the possibility of an actual infinite and yet assert that an infinite regress of past events is possible).

The number of events in the future of any event, however, can be a potential infinite if one embraces a dynamic (A-) theory of time. According to this theory, the members of a series of events come to be one after another, and the number of events which have happened would be increasing perpetually if the future is unending (although the number of events which have happened prior to any actual event(s), say the formation of our sun, would not be increasing perpetually but is a determinate whole, as noted above). By contrast, according to a static [B-] theory of time, the members of a series of events do not come to be one after another; rather the series of events is a tenselessly existing manifold all of whose members (including future events) are equally real. On a static theory of time, the future cannot be a potential infinite; it would be either finite or actually infinite.

In short, the number of events lying in the future of any event can be a potential infinite depending on what theory of time one adopts and whether the future is unending, but the number of events lying in the past of any event cannot be a potential infinite, because the past does not contain any potential events that have not been actualised. The key question to be addressed is whether the number of past events could be an actual infinite, and I shall now discuss the reasons for thinking that this is metaphysically impossible.

2.6 Craig's First Argument Against an Actual Infinite Past: The Impossibility of Concrete Actual Infinities

According to the great mathematician David Hilbert (1964, p. 151), 'The infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought… The role that remains for the infinite to play is solely that of an idea' (note that the 'infinite' referred to is an 'actual infinite', which is different from the doctrine of divine infinity).[1] Even though Hilbert is well aware of the actual infinite in modern set theories, yet he does not think that the actual infinite can exist in the concrete world. Over the last few decades Craig has developed and defended Hilbert's arguments. In particular, he has argued that the absurdities which result from paradoxes such as Hilbert's Hotel show that concrete infinities cannot exist, and since an infinite temporal regress of events is a concrete infinity, it follows that an infinite temporal regress of events cannot exist. Craig explains

Let us first imagine a hotel with a finite number of rooms. Suppose, furthermore, that all the rooms are occupied. When a new guest arrives asking for a room, the proprietor apologizes, 'Sorry, all the rooms are full,' and that is the end of the story. But now let us imagine a hotel with an infinite number of rooms and suppose once more that all the rooms are occupied. There is not a single vacant room throughout the entire infinite hotel. Now suppose a new guest shows up, asking for a room. 'But of course!' says the proprietor, and he immediately shifts the person in room #1 into room #2, the person in room #2 into room #3, the person in room #3 into room #4, and so on out to infinity. As a result of these room changes, room #1 now becomes vacant, and the new guest gratefully checks in. But remember, before he arrived, all the rooms were occupied! Equally curious, there are now no more persons in the hotel than there were before: the number is just infinite. But how can this be? The proprietor just added the new guest's name to the register and gave him his keys – how can there not be one more person in the hotel than before?…

But Hilbert's Hotel is even stranger than the German mathematician made it out to be. For suppose some of the guests start to check out. Suppose the guest in room #1 departs. Is there not now one fewer person in the hotel? Not according to infinite set theory! Suppose the guests in rooms #1, 3, 5, … check out. In this case an infinite number of people has left the hotel, but by Hume's Principle, there are no fewer people in the hotel. In fact, we could have every other guest check out of the hotel and repeat this process infinitely many times, and yet there would never be any fewer people in the hotel. Now suppose the proprietor does not like having a half-empty hotel (it looks bad for business). No matter! By shifting guests in even-numbered rooms into rooms with numbers half their respective room numbers, he transforms his half-vacant hotel into one that is completely full. In fact, if the manager wanted double occupancy in each room, he would have no need of additional guests at all. Just carry out the dividing procedure when there is one guest in every room of the hotel, then do it again, and finally have one of the guests in each odd-numbered room walk next door to the higher even-numbered room, and one winds up with two people in every room! One might think that by means of these manoeuvres the proprietor could always keep this strange hotel fully occupied. But one would be wrong. For suppose that the persons in rooms #4, 5, 6, … checked out. At a single stroke the hotel would be virtually emptied, the guest register reduced

> to three names, and the infinite converted to finitude. And yet it would remain true that as many guests checked out this time as when the guests in rooms #1, 3, 5, … checked out! Can anyone believe that such a hotel could exist in reality? (Craig and Sinclair 2009, pp. 109–110)

Critics have raised various objections to Craig's Hilbert Hotel's Argument. Landon Hedrick (2014), a critic, states Craig's argument as follows:

(A1) An actually infinite number of things cannot exist.
(A2) A beginningless series of events in time entails an actually infinite number of things.
(A3) Therefore, a beginningless series of events in time cannot exist.

Against A1, Hedrick suggests that there could be actual infinities in the world. He proposes that (1) there could be an infinite number of abstract objects—e.g., numbers propositions, properties, sets, possible worlds, etc. (2) David Lewis's modal realism view of possible worlds might be true, according to which there are an infinite number of concrete worlds; (3) space could be continuous, made up of an infinite number of points. With regards to (3), Hedrick writes

> Craig considers this possibility, but he imagines that his opponent must be trying to use this as a clear counterexample to (A1). His response is to point out that the notion that space is continuous is unproven (Craig and Sinclair 2009, 112). Seemingly, Craig thinks that it's up to his opponent to prove it. But again, Craig's premise seems to entail that space is not like this, which is also an unproven claim. True, if one could prove that continuous space is possible, then we'd have a counterexample to (A1). But since Craig is claiming that it's not possible, it's reasonable to expect him to prove it. (Hedrick 2014, p. 31)

Nevertheless, Hedrick seems to have misunderstood the burden of proof. In the context of Craig's opponent trying to use (3) or perhaps also (1) or (2) as a clear counterexample to (A1), which Craig attempts to justify with HHA, the burden of proof is on the opponent to justify (1), (2), or (3) as a genuine counterexample. In this context, Craig does not bear the burden of proof to offer separate arguments to show that (1), (2), or (3) are not possible. Rather, he only needs to show that there is no adequate reason to think that (1), (2), or (3) is metaphysically possible and relevant, hence there is no adequate reason to regard any of these as a genuine counterexample to his claim, which he justifies with HHA.

With regards to abstract objects, Craig has argued that there is inadequate reason to think that Platonism is true, and that the prospects of providing some overriding argument for the reality of mathematical objects, as well as rebutting defeaters of the abundant number of nominalist and conceptualist alternatives consistent with classical mathematics, are dim (Craig and Sinclair 2009, pp. 107–108). A similar response can be given with regards to David Lewis's modal realism view of possible worlds: there is no adequate reason to think that it is true, and that the prospects of providing some overriding argument for Lewis' view, as well as rebutting defeaters of the alternative views of possible worlds, are dim.

Even if abstract objects exist, a proponent of KCA can argue that the sort of arguments Hilbert and Craig offer are directed only against the existence of an actual infinite number of *concrete* entities, such as an actual infinite temporal regress of events. They are not directed against the existence of an actual infinite number of abstract entities.[2] This sort of move has been made, for example, by J.P. Moreland. He suggests that the problematic nature of paradoxes such as Hilbert's Hotel is related to the fact that: (1) the members of the set are finite, located, moveable entities, which opens up the possibility of adding, subtracting, or rearranging the members of the set; and (2) the members of the set are spatially extended. Since abstract entities are not finite, located, moveable entities nor spatially extended, the argument against the possibility of the actual infinite based on paradoxes such as Hilbert's Hotel does not apply to them (Moreland 2003, p. 379). Alternatively, one might suggest that the problematic nature of paradoxes such as Hilbert's Hotel is related to the fact that the members of the set are embedded in a network of causal relations (hence they could be moved around). Since abstract entities are not embedded in a network of causal relations, the argument against the possibility of the actual infinite based on paradoxes such as Hilbert's Hotel does not apply to them.

Distinguishing between abstract infinities and concrete infinities is therefore of importance. Concrete entities have causal powers and can be part of a chain of causes and effects. On the other hand, abstract infinities do not have causal powers, and therefore cannot account for the origin of things such as our universe. (To illustrate the fact that abstract infinities do not have causal powers: if someone asks, 'Where did the baby come from?', the answer cannot be 'Two', because 'Two' is an abstract number that has no causal power to produce anything. Rather, one might answer 'Two persons: the mother and the father', which are concrete entities capable of producing children.)

Let us now consider Hedrick's objection that space-time could be a continuum made up of actual infinite points. If spacetime is such a continuum, it would imply that there is a third instant of time between any two instants of time. This view has certain problematic consequences. For example, Robin Le Poidevin notes that this view rules out the possibility of discrete changes like the passage from existence to non-existence. Moreover, it implies that there are intermediate states where it is just indeterminate whether something exists or not (that is, there is no fact of the matter, not merely that we cannot discern what the facts are) (Le Poidevin 2003, pp. 114–115).[3]

On the other hand, Ellis notes that 'the often claimed physical existence of infinities is questionable… One can suggest they are unphysical; in any case such claims are certainly unverifiable.' He explains,

> The existence of a physically existing spacetime continuum represented by a real (number) manifold at the micro-level contrasts with quantum gravity claims of a discrete spacetime structure at the Planck scale, which one might suppose was a generic aspect of fully non-linear quantum gravity theories. In terms of physical reality, this promises to get rid of the uncountable infinities the real line continuum engenders in all physical variables and fields. There is no experiment that can prove there is a physical continuum in time or space; all we can do is test space-time structure on smaller and smaller scales, but we cannot approach the Planck scale. (Ellis 2007, Sect. 9.3.2)

Additionally, others have argued that discrete time (in which there are such things as chronons, i.e., smallest 'bits' of time) remains a defensible possibility (Van Bendegem 2011; Craig 2000a, pp. 239–244). Even if spacetime is continuous, one can argue that it is not made up of actual infinite points. Rather, it could be that spacetime is continuous yet naturally divide into finite number of smallest parts of finite durations (Loke 2016a; see next section).

An objector of Craig might argue that, according to the Standard Model of particle physics, fundamental particles appear to be points which have no physical extension and they are assumed to be such. Nevertheless, this has not been proven, and no one knows whether the Standard Model can stand the test of time. The unproven character of this assumption is shown by the fact that physicists are exploring alternative models such as those involving string theory, according to which particles do not exist at points but are instead vibrations of a string (Ford 2011, pp. 30–33, 257–258).

Against Craig, Swinburne (2004, pp. 138–139) objects that time could be made up of an actual infinite number of periods of unequal length, of 1/2 h, 1/4 h, 1/8 h, etc., which have already occurred during the past hour. Craig and Sinclair reply that this sort of objection can be met by distinguishing a potential infinite from an actual infinite. They explain

> While one can continue indefinitely to divide conceptually any distance, the series of subintervals thereby generated is merely potentially infinite, in that infinity serves as a limit that one endlessly approaches but never reaches… one's ability to specify certain points, like the halfway point along a certain distance, does not imply that such points actually exist independently of our specification of them…if we think of the line as logically prior to any points designated on it, then it is not an ordered aggregate of points nor actually infinitely divided. Time as duration is then logically prior to the (potentially infinite) divisions we make of it. Specified instants are not temporal intervals but merely the boundary points of intervals, which are always nonzero in duration. (Craig and Sinclair 2009, pp. 112–113)

While Richard Sorabji (1983, pp. 210–213, 322–324) asserts that the potentially infinite divisibility of a line (the property of being susceptible of division without end) entails that there is an actually infinite number of positions at which the line could be divided, Craig and Sinclair (2009, p. 114) point out that Sorabji's argument is guilty of a modal operator shift, inferring from the true claim

1. Possibly, there is some point at which *x* is divided to the disputed claim.
2. There is some point at which *x* is possibly divided.

Craig and Sinclair observes that it is coherent to maintain that a physical distance is potentially infinitely divisible without holding that there is an infinite number of positions where it could be divided (ibid.). While one might argue that it is possible to have a point in between any two points, it is logically invalid to infer from this to the conclusion that it is possible that an actual infinite number of concrete points can exist together. It is like arguing 'because a leaf could be any colour, therefore it can be every colour.'[4] A leaf obviously cannot be of every colour at the same time because of metaphysical constraints. Likewise, there might be metaphysical constraints that prevent all the points from existing together concretely, even if each point can exist concretely (I shall discuss the metaphysical constraint against concrete actual infinities below).

It might be objected that one can prove that there is an actual infinite between two points on a line, by showing that there are just as many real number of points between (say) 0 and 1 as there are between 0 and

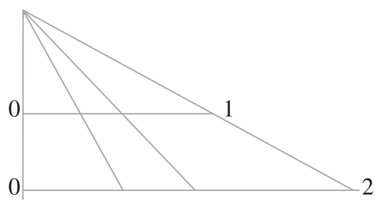

Fig. 2.1 Joining the points between 0 and 1 and the points between 0 and 2 in one-to-one correspondence. *Source* Wolchover (2013)

2 through joining these points in a one-to-one correspondence (four examples of joining are shown in Fig. 2.1).

In reply, this argument assumes that every point within the intervals (0, 1) and (0, 2) exists concretely, which begs the question against a concrete finitist who thinks that the points as well as the one-one correspondences merely exist as an abstraction. One could try to make these points concrete by drawing them (as the four examples of joining in Fig. 2.1 illustrate), but one would end up with a potential infinite rather than an actual infinite (i.e. the number of points drawn would increase with time towards infinity, but the number of points drawn would never reach an actual infinite number at any time).

Morriston (2002, p. 162) has argued that one could come up with a specification relative to which the number of coexistent sub-regions of a given region of space R is actual infinite, e.g., 'starting with R, divide the results of the previous division by half ad infinitum', and that we do not need to complete the series of divisions in order to know that, relative to this rule, there is an actual—and not merely a potential—infinity of sub-regions.

Proponents of KCA can reply to Morriston as follows: They can argue that their arguments are directed only against an actual infinite number of concrete entities such as an actual infinite temporal regress of events; they are not directed against an actual infinite number of abstract entities. As noted previously, distinguishing between abstract infinities and concrete infinities is of importance; concrete entities have causal powers and can be part of a chain of causes and effects, while abstract infinities do not have causal powers and therefore cannot account for the origin of things such as our universe. They can then reply to Morriston's Rule by arguing that an actual infinity of sub-regions exists only as an abstraction which we conceive relative to this Rule, but an actual infinity of sub-regions does not exist concretely in space itself. Rather, the series of divisions that is actually completed as well as the number of sub-regions that result in the concrete world is always finite.

Some have claimed that there are physically realised infinities in cosmology. For example, the current favoured cosmological model has zero curvature, meaning that space is flat. While some have assumed that a geometrically flat accelerating universe is indeed spatially infinite (Monton 2010), other cosmologists have replied that the flat space of the consensus model is probably an abstraction that does not hold physically (Halvorson and Kragh 2011). In addition, some scientists have argued that the flatness of space is unprovable, due to the inability to achieve an infinitely precise measurement and the limitations in the observability of the Universe by us. Even if space is flat, the infinity of space is unprovable, due to the inability to demonstrate that the FLRW metrics is maintained indefinitely beyond our cosmic horizon (Bersanelli 2011, pp. 201–203).

Ellis (2007, Sect. 9.3.2) points out that the assumption that space extends forever is unproved. He explains

> We may assume space extends forever in Euclidean geometry and in many cosmological models, but we can never prove that any realised 3-space in the real universe continues in this way—it is an untestable concept, and the real spatial geometry of the universe is almost certainly not Euclidean. Thus Euclidean space is an abstraction that is probably not physically real. The infinities supposed in chaotic inflationary models derive from the presumption of pre-existing infinite Euclidean space sections, and there is no reason why those should necessarily exist. In the physical universe spatial infinities can be avoided by compact spatial sections, resulting either from positive spatial curvature, or from a choice of compact topologies in universes that have zero or negative spatial curvature. (ibid.)

Wes Morriston (2002, p. 163) acknowledges that space is not Euclidean and not infinite, but he objects that, even if space is not in fact Euclidean, it seems obvious that it could have been, and that there are possible worlds in which parallel straight lines never meet and in which finite straight lines can be extended indefinitely, and in which space is actually infinite. However, a proponent of HHA can argue that HHA proves that there cannot be such worlds in the concrete realm, and that what 'seems obvious' to Morriston merely refers to abstractions which cannot be realised as concrete entities. As noted earlier, a proponent of HHA can accept that there are abstract actual infinities (such as a Euclidean space) but deny that there are concrete actual infinities.

Ellis (2007, Sect. 9.3.2) observes that 'The concept of infinity is used with gay abandon in some multiverse discussions, without any concern either for the philosophical problems associated with this statement, or for its completely unverifiable character. It is an extravagant claim that should be treated with extreme caution.' While singularities have been postulated as entities when infinite quantities appear, the actual existence of these have not been proven, and various proposals have been made for how singularities might be removed from scientific theories (Gambini and Pullin 2013).

Let us consider other purported examples of infinities in physics. Concerning Kelvin's absolute temperature scale, Oppy (2006, pp. 136–138) observes that 'While it is most convenient, all things considered, to adopt a system in which certain states are assigned infinite temperatures, the assignment of infinite temperatures is just a consequence of our choice of scale and does not indicate the existence of a genuinely problematic infinite quantity in the world.'

As for the renormalisation of infinities in quantum mechanics and quantum field theory, Oppy points out that this does not by itself demonstrate that there are infinities in nature, because arriving at a satisfactory understanding of physical particles and their interactions with physical fields is a very difficult task, and one that is still beset with difficulties. He writes 'Either we can understand renormalisation in terms of regularisation or there will be no renormalisation in theories of the world better than those that we currently possess. As things stand, it isn't obvious that there is anything in quantum field theory to encourage friends of concrete infinities' (Oppy 2006, 145; scientists have been developing methods leading to an infinity-free renormalisation, see, for example, Wu 2003).

Oppy notes that one can construct scientific models in which the large is approximated by the infinite, and/or the small is approximated by the infinitesimal, in order to obtain an advantage of some kind, for example, for computational tractability. He observes that such approximation has proven to be useful in addressing problems concerning pendulums, chemical decay, coagulation kinetics, diffusion, convection, economic equilibrium, and fluid flow. Nevertheless, 'in these cases, there is no commitment to the existence of infinite or infinitesimal quantities in nature, for the theory is merely a convenient approximation to reality in which everything is finite… these theories should be given a merely instrumentalist, or otherwise antirealist, interpretation' (ibid., pp. 150–151).

Against this anti-realist, interpretation, one might cite the Quine-Putnam indispensability argument, which implies that anyone committed to the truth of scientific theories that essentially involve infinitary mathematics is thereby committed to an ontological actual infinite. In reply, Penelope Maddy objects with a number of counterexamples:

> If we open any physics text with these questions in mind, the first thing we notice is that many of the applications of mathematics occur in the company of assumptions that we know to be literally false. For example… we assume the ocean to be infinitely deep when we analyze the waves on its surface; we use continuous functions to represent quantities like energy, charge, and angular momentum, which know to be quantized; we take liquids to be continuous substances in fluid dynamics, despite atomic theory. On the face of it, an indispensability argument based on such an application of mathematics in science would be laughable: should we believe in the infinite because it plays an indispensable role in our best scientific account of water waves? (Maddy 1997, p. 143)

With respect to the L'Hospital's (1661–1704) view that a curve may be regarded as the totality of an infinity of straight segments each infinitely small or as a polygon with an infinite number of sides, A.W. Moore notes that 'it was steeped in the kind of confusion that came with a completely uncritical acceptance of the infinitely small' (Moore 2001, pp. 65–66). He observes that Eudoxus and Archimedes had shown that, when using this method, we did not need to think of a curved figure as an infinigon. Rather, we could see it as the limit of a sequence of polygons, which we must in turn understand in terms of generalisations. That is, the larger the number of sides of the polygon, the closer it is to a curve, but there will always be a finite value to the angle between the sides and it will never become a curve (ibid.). Moore points out that mathematicians using calculus can uphold claims ostensibly about infinitesimals or about infinite additions, knowing that they are only making disguised generalisations about what are in fact finite quantities (ibid., p. 73). Stanford mathematician Solomon Feferman observes that

> infinitary concepts are not essential to the mathematization of science, all appearances to the contrary. And this also puts into question the view that higher mathematics is justified by science or is somehow embodied in the world, rather than that it is the conceptual edifice raised by mankind in order to make sense of the world' and 'the actual infinite is not required for the mathematics of the physical world. (Feferman 1998, pp. 19, 30)

While infinities are useful mathematically, that does not imply that concrete infinities exist, just as the fact that imaginary numbers (e.g., $\sqrt{-1}$) are mathematically useful does not imply that that they correspond to concrete entities (they obviously don't!). Infinities, like imaginary numbers, can be regarded as useful abstract tools.

In summary, there is no adequate reason for concluding that any of the above examples taken from the fields of philosophy, physics, geometry and mathematics is a concrete infinite, and there is insufficient justification for thinking that it is metaphysically possible that concrete infinities exist.

But are there adequate reasons for thinking that concrete actual infinities such as an actual infinite past cannot exist? As noted previously, Craig has attempted to argue for a beginning of the Universe based on the impossibility of concrete actual infinities using the Hilbert Hotel Argument. With regards to Hilbert's Hotel's ability to accommodate new guests by shifting rooms even though it is full, critics object that this is what ought to be expected of a hotel with an infinite number of rooms; to assume otherwise would be to beg the question against the existence of an actual infinite (Oppy 2006, p. 48; Philipse 2012, p. 224). After all, mathematicians Richard Dedekind (1963, p. 63) and Geog Cantor (1915, p. 108) have already defined a set as infinite when a part of it is equivalent to the whole, that is, when a part of it can be put into a one-to-one correspondence with the whole, and as noted previously this is understood similarly in modern day Zermelo–Fraenkel axiomatic set theory. Dedekind (1963) had also argued that the Euclidean maxim that the whole is greater than a part holds only for finite systems. Philipse claims that

> Geog Cantor showed… these paradoxes of infinity arise because one mistakenly conceives of infinite sets on the model of finite sets. In order to avoid such confusions, infinite sets should be defined explicitly as sets that can be paired in a one to-one correspondence with a proper subset…After Cantor's elimination of the traditional paradoxes of infinity, it seemed to mathematically informed philosophers that the First-cause cosmological argument had been refuted conclusively. (Philipse 2012, p. 224).

Philipse thinks that Hilbert's hotel seems paradoxical merely because 'such things are physically impossible on Earth, so that it is perhaps psychologically impossible to imagine them' (ibid., pp. 225–226).

Mathematician James East (2013) argues that inverse operations of subtraction and division with infinite quantities do not lead to contradictions; they only lead to indefinite answers as one could get different answers depending on which objects one chooses to take away. Other opponents to KCA have argued that, even if a hotel with an infinite number of rooms is impossible, it does not follow that there cannot be other kinds of concrete infinities such as an infinite temporal regress of events (Morriston 2003, pp. 296–297; Hedrick 2014).

In a number of recent papers, I have replied to the above objections. I shall briefly summarise my arguments here.

To begin, the sort of reply East offers by no means proves that concrete actual infinities are possible. It should be noted that what is mathematically possible is not always metaphysically possible. For example, the quadratic equation $x^{2-4} = 0$ can have two mathematically consistent results for 'x': 2 or -2, but if the question is 'how many people carried the computer home', the answer cannot be '-2', for in the concrete world it is metaphysically impossible that '-2 people' carried a computer home. Thus the conclusion of ‘2 people’ rather than ‘−2 people’ is not derived from mathematical equations alone, but also from metaphysical considerations: ‘−2 people’ lack the causal powers to carry a computer home. This shows that metaphysical considerations are more fundamental than mathematical considerations (Loke 2016e). In other papers (Loke 2012, 2014b, 2016c), I have offered metaphysical considerations against the possibility of certain kinds of concrete infinities such as an actual infinite past. I shall explain these considerations below.

Suppose there is a ‘Christmas present generator’ which has been generating similar Christmas presents at fixed temporal intervals as long as time existed. Suppose there is also a ‘person generator’ which has been generating persons at the same fixed temporal intervals as long as time existed. Suppose that the presents and the persons continue existing after they have been produced. I argue that the presence or absence of leftover presents should be independent of each person grabbing one present produced at any particular instant, because (P) each person grabbing one present from one temporal position rather than another has no causal power with respect to the presence of leftover presents.

It is uncontroversial that P is metaphysically necessarily true for finite sets. The crucial question to ask is whether P is metaphysically necessarily true only for finite sets, or is it metaphysically necessarily true for ‘any set with any number of concrete members’ that can exist. I argue that it is a metaphysically necessary principle that the causal powers of a set of things ultimately depend on the things in the set and not the number in conjunction with the things. For example, suppose that a certain thing Z has zero mass. In this case, either a set of ‘twenty’ or ‘ten’ Zs would not make a difference to the reading on the weighing scale, because $20 \times 0 = 0$ and $10 \times 0 = 0$. And in cardinal arithmetic of Set Theory, infinity $\times\ 0 = 0$, because the product of any set A with the empty set is the empty set (Infinity $\times\ 0$ is not equal to 0 if we are talking about infinity as a limit, but the concept of infinity as a limit is not relevant here; what we are discussing here concerns a set of entities, and thus we should be talking about infinity as understood in set theory rather than as a limit).

The point is that whether a set of things has a certain causal power or not ultimately depends on the things (in the case of the Christmas present scenario, a thing = 'each person subsequently grabbing one present from one position rather than another'), and not the number in conjunction with the things. (Let us call this metaphysical fact F. It should be noted that this metaphysical fact is not based on whether a concrete infinite can exist or not; rather it is based on the abstract nature of numbers. Hence, this metaphysical fact does not beg the question against concrete infinities.) 'Number' is a mere abstraction of the things that exist in the set, and the 'number' of a set of things is not the sort of entity which in conjunction with the things in the set would have certain causal power that the things would not have had. Since that is the case, it cannot be claimed that the *abstract number n* (whether finite or infinite) of person-present in conjunction with 'each person subsequently grabbing one present from one position rather than another' would make a difference concerning the presence or absence of causal power with respect to leftovers.[5] Rather, the presence or absence of such causal power would ultimately depend on whether 'each person subsequently grabbing one present from one position rather than another' has any causal power, and the abstract number *n* would be irrelevant. Hence, the number of physical things in a set should not matter where the range of P over *z* is concerned. Now we know that P ranges over any *z* where *n* is finite (both friends and opponents of infinity are agreed on this). However, since *n* is irrelevant, it is not the case that P ranges over any *z* only where *n* is finite; on the contrary, it is the case that P ranges over any *z* for any *n*. Hence, P is

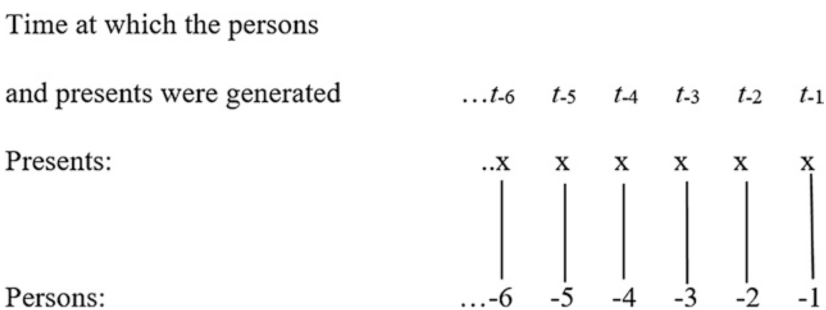

Fig. 2.2 Persons grabbing presents this way

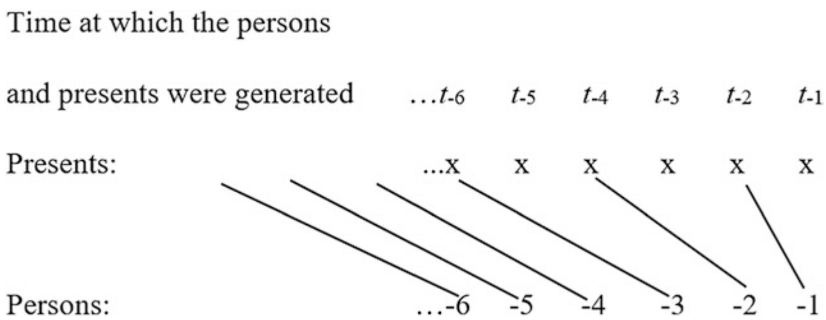

Fig. 2.3 Persons grabbing presents this way

metaphysically necessarily true, not merely 'for finite sets', but for 'any sets with any number of members' that can exist.

I go on to explain that P will be violated if there were an actual infinite past: suppose at time t_0 the person who was generated at t_{-1} picked up the present generated at t_{-1}, the person who was generated at t_{-2} picked up the present generated at t_{-2}, the person who was generated at t_{-n} picked up the present generated at t_{-n}…as follows (Fig. 2.2):

If there were an infinite temporal regress of events, the result is that there would not be an infinite number of presents left.

However, if they had grabbed the presents this way: the person who was generated at time t_{-1} picked up the present generated at t_{-2}, the person who was generated at t_{-2} picked up the present generated at t_{-4}, the person who was generated at t_{-n} picked up the present generated at t_{-2n}… as follows (Fig. 2.3):

If there were an infinite temporal regress of events, what happens is that each person would walk away with one present, and there would be an infinite number of presents left! The problem arises from the postulation that these generators existed from an actual infinite past, for if they did not exist from an actual infinite past, such situations which violate metaphysical necessity truth P would not have arisen.

Note that such a violation remains even if, as Oppy (2016, p. 88) suggests, we vary other features of the story. For example, we can vary other features such as stipulating dogs instead of persons and bones instead of presents, and the violation will still persist. Thus, my argument does not depend on persons or Christmas presents; the illustration using persons and Christmas presents are merely conceptual tools which help us to understand the metaphysics involved. However, it is obvious that in this scenario, so long as the temporal regress of events is infinite, the violation will persist, but if the regress were finite, no such violation would occur. Therefore, the violation of metaphysical necessity is related to the assumption of an infinite temporal regress of events. Hence, an actual infinite temporal regress of events is metaphysically impossible.

It is important that neither the opponent nor friend of infinity should beg the question in the dialectic. On the one hand, it should be noted that 'entailment' is different from 'basis': while metaphysical fact F entails the rejection of concrete infinities, it is not based on the rejection of concrete infinities. Rather it is based on the independent reason that numbers are causally inert in the sense explained above. My argument is not based on the presupposition that concrete infinities cannot exist (if it were so, it would be begging the question). Rather, my argument is based on the independent reason that numbers are causally inert, and therefore it does not beg the question. On the other hand, a friend of infinity should not beg the question by simply asserting that 'concrete infinities do not obey P, therefore the argument is fallacious'. For to argue this way would be to presuppose that concrete infinities can exist, which is precisely what is being denied by the opponent. A friend of infinity should also not simply say 'Infinite collections behave differently from finite collections.' Of course, infinite collections (if they exist) could have properties that are different from finite sets, but the problem is that certain infinite collections would have properties that violate metaphysical necessity if they were to exist in the concrete world; therefore they cannot exist in the concrete world but only in the abstract realm. Additionally, a friend of infinity should not simply claim that 'it is unproblematic that there could be causal capacities present in infinite collections that are not present in finite collections, thus if metaphysical fact F entails the rejection of this unproblematic claim, then it would be question-begging to insist on metaphysical fact F in this context'. For to claim that 'it is unproblematic that there could be causal capacities present in infinite collections that are not present in finite collections' would be to beg the question against the opponent who argues that this claim is problematic, on the basis that it violates the metaphysical principle that whether a set of things has certain causal power or not ultimately depends on the things.

In short, a friend of infinity should not beg the question in the dialectic by merely presupposing that concrete infinities can exist, and insists that the entailment of violation of P by a concrete infinite serves as a counterexample to the opponent's argument. Rather, she would have to rebut the independent reason the opponent offers as the basis for the opponent's argument, and the independent reason in this case would be the fact that numbers are causally inert in the sense explained above. To rebut this, a friend of infinity might try to argue that an actual infinite number does have independent causal powers. However, it is evident that numbers do not have causal powers; numbers do not—apart from the concrete particulars that they are of—bring about the existence of, say, minds, babies, universes. To claim that an actual infinite number has causal powers such that it can actually produce infinite leftovers by acting on the persons' actions in grabbing the presents from certain positions, which otherwise do not have causal power with respect to leftover presents, is really to claim that such numbers are concrete particulars with highly active causal powers of their own. If this claim were true, such a number would not be abstract anymore; rather it would be something that is concrete and existing alongside the sets of presents and people! But of course, numbers are not concrete particulars which exist alongside the concrete particulars that they are of.

Hence, it would be problematic for a 'friend of infinity' to embrace the reductio of my argument by claiming that the 'absurd situations' in my Christmas present illustration are just what one ought to expect if there were concrete infinities (this move is made by Oppy [2006, p. 48] in response to Craig). The problem is not (as Philipse thinks) that such things are physically impossible on Earth or that it is psychologically impossible to imagine them. Rather the problem is that such things entails the violation of metaphysical necessity. My argument is not based on conceiving infinite sets on the model of finite sets (cf. Philipse's objections concerning the paradoxes of infinity), rather it is based on metaphysical fact F which is applicable to any concretely existing set.

Against Craig, Swinburne (2004, pp. 138–139) suggests that we can allow an infinite number of things without adopting Cantor's mathematics or a particular kind of way of applying it. Likewise, Guminski (2002) contends that one can have actual infinites in the real world if one abandons the standard way of applying set theory to real objects. With respect to actual infinities, Pitts (2008, p. 683) argues (in reply to KCA) that one might deny that cardinality exhausts the notion of sameness of size.

Such replies merely sidestepped the deeper metaphysical problems with an actual infinite temporal regress which I explained above. Consider the problematic situation I describe:

1. If the person who was generated at t_{-n} picked up the present generated at t_{-n}, there would be no leftover.
2. If the person who was generated at t_{-n} picked up the present generated at t_{-2n}, there would be an actual infinite number of presents left over.

For (1), the conclusion that there would be no leftover is unavoidable.

For (2), the conclusion is likewise unavoidable. If there were no present generated at t_{-2n} available for the person who was generated at t_{-n} to grab, then there would have been presents lacking from the set and the set would not have been actually infinite. This would imply that there was not an actual infinite temporal regress of events in the scenario involving the present-generator in the first place, for otherwise there would not have been presents lacking. Additionally, if there were no actual infinite number of presents leftover, then there would have been presents lacking from the set and the set would not have been actually infinite.

Given that the conclusions of (1) and (2) are unavoidable, the aforementioned violation of metaphysical necessity which they jointly entail is likewise unavoidable. The metaphysical problem with concrete infinities therefore cannot be avoided by quibbles about cardinalities, Cantor's mathematics or the kind of way of applying it.[6] The problem is not due to our human inability to conceive a concrete infinite, rather (as I have explained) it is due to the nature of concrete infinities itself.

2.7 Craig's Second Argument Against an Actual Infinite Past: The Impossibility of Traversing an Actual Infinite

Craig has offered another argument against an actual infinite past, namely the argument against the possibility of traversing an actual infinite. In *The Blackwell Companion to Natural Theology*, Craig formulates the second of his philosophical arguments for a beginning of the Universe as follows:

1. A collection formed by successive addition cannot be an actual infinite.
2. The temporal series of events is a collection formed by successive addition.
3. Therefore, the temporal series of events cannot be an actual infinite (Craig and Sinclair 2009, p. 117).

Some philosophers have objected to Craig by utilising Zeno's paradoxes of motion and claiming that actual infinite sequences are 'traversed' all the time in nature, for example, claiming that whenever an object moves from one location in space to another it must pass through an infinite number of halfway points.

Craig replies by noting that the argument for the impossibility of traversing an actual infinite has two crucial dys-analogies with Zeno's paradoxes of motion. In the case of Craig's argument, the events in a temporal series are actual. Moreover, the events would have to sum up to an actual infinite magnitude in order to avoid a beginning. By contrast, in the case of Zeno's paradoxes, the interval traversed could be regarded as being potentially infinitely divisible and not actually infinitely divided.[7] In other words, one can keep on dividing the interval by half without ever ending up with an actual infinite number of units. Craig argues that 'The claim that Achilles must pass through an infinite number of halfway points in order to cross the stadium already assumes that the whole interval is a composition of an infinite number of points' (Craig and Sinclair 2009, p. 119),[8] an assumption for which we have inadequate evidence as argued previously in Sect. 2.6.[9] Moreover, the points that Achilles must pass through sum to a distance that is of merely finite magnitude (Craig and Sinclair 2009, p. 119; see also Aristotle *Physics*, 239b5–32; 263a26–b8).

Likewise, the argument has crucial dys-analogies with an ordered set of real numbers having infinite elements but no first element. An ordered real set can be regarded as abstract rather than concrete. Additionally, the elements summed up to a finite distance (e.g., between 0 and 1). Therefore an ordered real set cannot be used to avoid a finite past which (in the context of the KCA) would require a timeless First Cause (see Chaps. 4, 5 and 6).

There have been speculations concerning the possibility of supertasks, i.e., various thought experiments involving the completion of an infinite number of tasks in a finite time by performing each successive task during half the time taken to perform its immediate predecessor.

In response, on the one hand, such supertasks assume that time is a continuum and that a finite time interval consists of an actual infinite number of instants. However, this assumption has not been proven, as noted previously.

On the other hand, Craig has argued that there are reasons for thinking that such supertasks are metaphysically impossible. Aside from his argument against concrete infinities (see previous section), which implies that there cannot be an actual infinite number of tasks performed in the concrete world, there is the problem of causal disconnection. Craig explains

> The fatal flaw in all such scenarios is that the state at $\omega + 1$ is causally unconnected to the successive states in the ω series of states. Since there is no last term in the ω series, the state of reality at $\omega + 1$ appears mysteriously from nowhere. The absurdity of such supertasks underlines the metaphysical impossibility of trying to convert a potential into an actual infinite. (Craig and Sinclair 2009, p. 117, n. 15)[10]

Consider, for example, a man crossing the slabs in progressively shorter intervals, the first in a half-minute, the second in a quarter-minute, the third in an eighth of a minute, etc. Craig thinks that this scenario is a fantasy, for the state of reality at $\omega + 1$ appears mysteriously from nowhere; the man cannot reach the slab numbered $\omega + 1$ without having stepped there from the immediately preceding slab, but there is no preceding slab to $\omega + 1$! Craig argues that the denial that there must be an immediately precedent is hardly a refutation of the claim that, given a series formed throughout by successive addition, the state of a physical object at $\omega + 1$ must be causally connected with an immediately preceding state (Craig 2011).

Against Craig, Puryear thinks that Craig and Sinclair (2009, pp. 112–113)'s view that time as duration is logically prior to the potentially infinite divisions we make of it involves the idea that time is prior to any parts we conceive within it (Priority of the Whole with respect to Time: PWT). He argues that PWT entails the Priority of the Whole with respect to Events (PWE), and that it subverts the argument against an eternal past. 'For if events do not divide into parts except in so far as we divide them in thought, then we must admit that just as time is in itself merely one long interval, the history of the Universe up to the present is in itself just one long event' (Puryear 2014, p. 627).

In a subsequent article 'Finitism, Divisibility, and the Beginning of the Universe: Replies to Loke and Dumsday,' Puryear (2016) addresses the three objections which emerge from the replies to his earlier article. The first two objections concern the distinction between infinite magnitudes and infinite multitudes, and the distinction between extensively and intensively infinite progressions. The third objection concerns the possibility that time might be continuous yet naturally divide into finite number of smallest parts of finite durations (Loke 2016a).

There are multiple problems with Puryear's responses to these objections.

Puryear writes 'A key claim of my argument is that, if time divides into parts only in so far as we divide it, then reaching the present in a universe without beginning would not require traversing an actually infinite multitude of intervals or events. "At most, it would require traversing an infinite magnitude, something to which finitists have typically raised no objection" (Puryear 2014, p. 628).

This statement is not accurate. As noted earlier, Craig and Sinclair (2009, p. 119) have pointed out previously that one of the dys-analogies with Zeno's paradox is that in the case of Zeno's paradoxes, the sub-intervals traversed sum to a merely finite distance, whereas the intervals in an infinite past sum to an infinite distance. This point is of significance in the context of discussing the KCA. The reason is because summing to a merely finite magnitude would imply that the past is finite and thus (according to proponents of the KCA) require a cause. As Craig and Sinclair (2009, pp. 102, 185–186) write, one of the premises of the KCA is that 'everything that begins to exist has a cause', and in their view 'something has a beginning just in case the time during which it has existed is finite' (Craig makes the latter point in the context of explaining that beginning to exist does not entail having a beginning point).

Concerning the possibility that time might be continuous yet naturally divide into smallest parts of finite durations, Puryear claims that my view that time divides into 'distinct periods that exist apart from our conceptual activity' (Loke 2016a, p. 592) seems to entail that time is discrete. He supposes that we have a period of time that begins at t_a and ends at t_d, and which naturally divides into two parts, t_a–t_b and t_c–t_d. He argues that, in order to avoid discrete time, t_a, t_b, t_c, and t_d should be regarded as instants and that $t_b = t_c$, which implies that the instant at which the first part of t_a–t_d ends is the same instant at which the second part begins. He asks if that is the case, then what makes these really distinct parts as opposed to parts that we merely conceive in that period. He concludes that 'it would seem that an objectively real division would result in non-overlapping parts. But how could time divide into non-overlapping parts and yet still be continuous?' (Puryear 2016, p. 811).

In reply, the entailment of discrete time does not follow. The answer to the question 'what makes these really distinct parts as opposed to parts that we merely conceive in that period' is simple: these parts are distinct in virtue of having different properties. Consider Aristotle's view that things neither move nor rest at a point, but instead move or rest only during an interval (*Physics* 232a324). Suppose something moves at t_a–t_b and rests at t_c–t_d. In that case the two parts are distinct in virtue of having something moving in the first part and having the same thing resting in the second part. Given that there is an objective distinction between moving and resting, there are objectively two distinct periods within t_a–t_d. These periods are continuous in virtue of being joined together at $t_b = t_c$.

Puryear notes that I have previously argued that parts that are really distinct can be 'joined together' at the same extensionless instant in the following way:

> To illustrate one possible way of joining temporal parts, consider Aristotle's view that things neither move nor rest at a point, but instead move or rest only during an interval (Physics 232a324). The extensionless 'point of transition', which we conceptualise between 'moving interval' and 'resting interval', can be understood as the coincidence of the boundaries of the two intervals at which they join together; and, as Aristotle explained, there is neither motion nor rest at this (or any) point. (Loke 2016a, p. 594)

Puryear (2016, p. 811) objects that my phrase 'the extensionless "point of transition", which we conceptualise' implies that 'apart from our conception, there is no point of intersection, no coinciding boundaries, and thus no division.'

In reply, on the one hand, my phrase does not deny that the 'point of transition' can exist apart of our conception. On the other hand, I evidently intend the coincidence of the boundaries to be understood as a mind-independent reality at which the two intervals join together, and not merely something that we conceptualise. Puryear cites Aristotle and claims that he 'seems to hold that any such transition point could be only a potential division in time, since on his view actual divisions introduce discontinuities [*Physics*, VIII.8, 263a2330]' (ibid.). However, an actual division of t_a–t_d into two parts t_a–t_b and t_c–t_d should not introduce discontinuities, since $t_b = t_c$. The two parts are distinct but not separated.

Finally, Puryear claims that

> the finitist has not yet established the crucial premise that a beginningless past would consist in an infinite sequence of events (rather than one simple event that we divide in thought). In other words, in order for the finitist argument to go through without falling prey to the Zeno objection, the finitist needs time to have smallest natural parts. But if all that has been shown is that time could have smallest natural parts, not that it does have such parts, then temporal finitism has not been established. In

> order to fully vindicate the finitist argument, then, Loke and Dumsday not only need to say more in support of the coherence (and indeed the plausibility) of their alternative conceptions of time; they also need to show that the conceptualist alternative is not plausible, or at least that it is comparatively implausible. Until that has been done, the case for the finitist argument remains at best incomplete. (Puryear 2016, p. 812)

In reply, it should be noted that Puryear (2014, p. 625) accepts the view that events are changes, saying that it is 'the most intuitively plausible of the theories philosophers have defended.' It is evident that more than one change has occurred in the history of the Universe. For example, Puryear's original paper has undergone a number of changes since he presented an earlier version of it at the 2014 North Carolina Philosophical Society Meeting at UNC-Chapel Hill. Additionally, our conceptual activity itself has undergone multiple changes. Thus the conceptualist view that the past is one simple event that we divide in thought is not plausible.

Moreover, even if the past consists of only one simple event that we divide in thought, it still remains the case (as I argue below) that, if time is beginningless, then it would be the case that a causal series which has members being generated one after another as long as time exists would arrived at an actual infinite of generations of members at a particular point in time. The metaphysically impossibility of the consequent—which proponents of KCA will argue for—would still imply the metaphysically impossibility of the antecedent (a beginningless past). Thus, the conceptualist view of time does not block the finitist's argument against an eternal past in any case.

In summary, the abovementioned objections to the argument against traversing an actual infinite do not succeed. Nevertheless, a limitation of Craig's formulation of the argument, as he himself notes, is that its second premise presupposes a dynamic (A-) theory of time (Craig and Sinclair 2009, p. 124). This limitation makes the argument unacceptable for those who do not hold this theory of time. To persuade these people, one would have to first show that the dynamic theory is preferable to the static theory of time—not a straightforward task considering the vast amount of literature on static versus dynamic theory of time.

(It should be noted, however, that Craig has defended the dynamic theory in a number of publications. See, for example, Craig [2000a, 2000b]. The issue concerning these theories of time is further discussed in the subsequent chapters of this book.)

This problem can be addressed by reformulating the argument against traversing an actual infinite in such a way that it remains valid on static theory of time, as follows:

1. If time is beginningless, then it would be the case that a causal series which has members being generated one after another as long as time exists would arrived at an actual infinite of generations of members at a particular point in time.
2. It is not metaphysically possible for a causal series which has members being generated one after another as long as time exists to arrive at an actual infinite of generations of members at a particular point in time.
3. Therefore, it is not metaphysically possible that time is beginning-less.

The justification for premise 2 is that an actual infinite has greater number than the number of durations and generations of causes-and-effects which can be arrived at one-after-another in time. To illustrate: Suppose George begins to exist at t_0, he has a child at t_1 who is the first generation of his descendants, a grandchild at t_2 who is the second generation, a great-grandchild at t_3 who is the third generation, and so on. The number of generations and durations can increase with time, but there can never be an actual infinite number of them at any time, for no matter how many of these there are at any time, there can still be more: If there are 1000 generations at t_{1000}, there can still be more (say 1001 at t_{1001}); If there are 100,000 generations at $t_{100,000}$, there can still be more (100,001 at $t_{100,001}$), etc.

The number of generations at any time is finite, to which there can be more at a later time, and this is true regardless of whether time is dynamic or static. What this illustrates is Principle P: An actual infinite has greater number than the number of durations and generations of causes-and-effects which can be arrived at one-after-another in time. (Note that 'arrived at' can be understood tenselessly as follows: An entity E arrived at t_0 from t_{-2} via a process = E exists at t_{-2}, t_{-1}, and t_0, and the states of E at t_{-2}, t_{-1}, and t_0, are different in a definite manner, with the result at t_0.) It should be noted that P is based on: (i) the nature of the number of elements of an actual infinite set, which is an essential property of such a set; and (ii) the nature of a 'one-after-another' process, which is an essential property of such a process. Thus, P is true regardless of whether the generations are future or past.

Since it is impossible to (1) reach an actual infinite number of durations and generations from George's generation (the reason being that the number of durations and generations required is greater than the number of one-after-another finite durations which can be arrived at any time), it is likewise impossible to (2) reach George's generation from an actual infinite number of previous durations and generations given that the number of durations and generations required is the same as (1). Thus, there must be a First Cause and a beginning of time.

One might object 'if we adopt a static theory of time in which the series of events is a tenselessly existing manifold all of whose members (including future events) are equally real, and if we further postulate that time is infinitely long, then it is false that one more generation can always be added to what exists, since an infinitely many generations already exist.'[11] In reply, on the one hand, one must be careful not to assume that time is indeed infinitely long, since this would be begging the question in favour of infinite time. On the other hand, the objection ignores the problem which concerns the concrete parts of the series in time. The problem does not concern whether one more generation can always be added to what exists, but whether an actual infinite number of generations can be arrived at any time. The objector suggests the hypothesis of a series that is infinitely long. However, to arrive at an actual infinite number of generations in the first place one needs to first proceed one generation after another, and the problem is that the result of that process is always finite at any time. One does not arrive at an actual infinite at any time, not at t_{1000}, t_{100000} or $t_{1000000}$. Time t_{infinite} cannot be in the series. Actual infinite stands outside of the series, timelessly and abstractly. But here we are talking about what happens in a series in the concrete world which exists in time, not timelessly and abstractly. In the concrete world there is never an actual infinite number of generations at any time.

It is instructive to note the difference between a causal series and a number series. Some have attempted to object to the argument against an infinite regress by appealing to a negative number series as a counterexample. For example, Bertrand Russell (1969, p. 453) argues that there could be an actual infinite series of negative integers ending with minus one and having no first term. Likewise, Graham Oppy asks us to consider the series ..., $-n$, ..., -3, -2, -1. He writes 'In this series, each member is obtained from the preceding member by the addition of a unit' (Oppy 2006, p. 117). Smith and Oaklander (1995, p. 16) argue that there could be an infinite number of years in the past: while each year is only finitely distant from the present year, there are an infinite number of finitely distant years, and that is all it means to say the past is infinite. They explain 'it is like the negative number series. Every negative number, be it minus 65 or minus one trillion, is separated from zero by a finite number of negative numbers, but it is nonetheless truth that there are an infinite number of negative numbers.'

In reply, some proponents of KCA might defend nominalism and deny the reality of mathematical objects. Alternatively, one might argue that, even if a negative number series exists, this is dys-analogous to an actual infinite temporal regress in a crucial way. A negative number series is a case of abstract actual infinite which exists timelessly rather than as a one-after-another temporal process. Thus, it does not provide a counterexample to the claim that an actual infinite cannot be arrived at via a one-after-another temporal process in the concrete world. While each member of the abstract negative number series ..., $-n$, ..., -3, -2, -1 is obtained from the preceding member by the addition of a unit, this obtaining is in the form of timeless mathematical relation. It is not the case that the abstract number –2 (say) is brought into existence in time by the addition of a unit to –3. Rather the abstract numbers –2 and –3 have always existed timelessly, and this is unlike a causal series of concrete entities existing in time. One can have an abstract actual infinite number of negative numbers each of which is timelessly separated from zero by a finite number of negative numbers. The existence of each of the number in the series is not causally dependent on any previous number, nor is it dependent on the actual infinite number which exists outside of the series. However, to arrive at the present by a one-after-another causal process is a different matter. In contrast with timeless numbers, causes-and-effects are arrived at in time, and each effect in time is causally dependent on a prior cause. The process proceeds one after another, arriving at a finite result at any time. As noted earlier, actual infinite stands outside of the series, timelessly and abstractly. But here we are talking about what happens in a series in the concrete world which exists in time, not timelessly and abstractly.

The objector might attempt to deny principle P by arguing that it does not hold if we are talking about arriving at the present from the past. The objector might argue as follows: Suppose George begins to exist at time t_0, his father at t_{-1}, his grandfather at t_{-2}, his great-grandfather at t_{-3}, and so on. If there is an actual infinite temporal regress, then there would be no starting point whatever (Sobel 2004, p. 182). And if this series is beginningless, then it would not be the case that the number of generations of causes-and-effects and finite durations at any time which can be arrived at via a one-after-another process is finite. For in this case there would be an actual infinite number of generations of causal antecedents at a particular point in time (i.e., t_0), by having generations of causal antecedents at certain time intervals in a beginningless series. The objector might therefore insist that P should be restated as follows:

(P′) An actual infinite has greater number than the number of durations and generations of causes-and-effects which can be arrived at one-after-another in time *iff time has a beginning*.

The objector might object that my argument ignores the biconditional 'iff time has a beginning,' and that my argument begs the question against an actual infinite past because it is based on the assumption that time has a beginning.

However, this objection will not work.

To begin, we must be careful not to confuse biconditionals with basis. The fact that both conditionals of a biconditional holds together does not always imply that one is the basis of the other. Consider the following example involving the laws of logic: 'Violations of laws of logic are impossible iff there cannot be such things as shapeless cubes.' Here the two conditionals hold together. However, the claim that 'violations of laws of logic are impossible' is not simply based on assuming that there cannot be such things as 'shapeless cubes'—which will be begging the question against an objector to the laws of logic! Rather it is based on an independent reason in the form of a deeper explanation such as the following: contradictories (e.g., 'shapeless' and 'cube') cancel each other out; it is like writing something and immediately erasing it, such that there is nothing.

This example shows that appealing to biconditionals proves nothing in the dialectic and confuses the discussion. What we really need to look for are independent reasons and deeper explanations concerning the nature of things in question, and to use these reasons and explanations as basis to justify one position over the other.

On the one hand, one must be careful not to deny or affirm P by simply assuming that time can or cannot be beginningless in the dialectic, for to do that would be to beg the question. And one must not deny or affirm P by simply assuming that George could or could not have an actual infinite number of ancestors, since this assumption is being disputed. The statement 'if the series is beginningless, then it would be the case that one can arrive at an actual infinite number of generations of causes-and-effects' does not imply that it is indeed the case that one can arrive at an actual infinite number of generations of causes-and-effects. To assume that this is the case, one would be moving illicitly from 'if the series is beginning-less' to 'the series is beginningless', which begs the question in favor of beginningless time.

On the other hand, one can offer an independent reason (independent in the sense that it is not based on whether George could or could not have an actual infinite number of ancestors) for thinking that it is metaphysically impossible that George has an actual infinite number of ancestors. We need to ask how any concrete series is constituted in the first place. Without begging the question either way by presupposing whether the past is infinite or not, think of a series of ancestors-and-descendants in the midst of producing more generations of descendants.

time	t_p	t_q	t_r	t_s
	→generation P	→generation Q	→generation R	→generation S

Here we are looking at the process without presupposing whether the previous or future generations are infinite or not. Generation P is produced at time t_p, generation Q at time t_q, generation R at time t_r, and generation S at time t_s. The nature of the process is such that there is one generation produced at t_p, there are two generations produced at t_p and t_q, there are three generations produced at t_p, t_q and t_r, etc.[12] The number of generations is constituted by each generation. The series is constituted by the parts. To constitute a series one need to first proceed one generation after another. The series is constituted by a finite number ('one') following another finite number ('another'), and together they constitute a finite number of generations. There is no actual infinite number of generations constituted at any time.

The objector might argue that, if one add a finite number to a finite number and repeat the operation an actual infinite number of times, one gets an actual infinite result. In reply, the question is whether we can repeat an operation an actual infinite number of times in the first place. To repeat an operation actual infinite number of times, one needs to first proceed one time after another, but the problem is that the result of that process is always finite at any time. As noted previously, certain mathematical entities (e.g., $\sqrt{-1}$) can exist in the abstract realm of mathematics but cannot be exemplified by anything in the concrete world. Likewise (I have argued) for an actual infinite number of finite operations. As noted earlier, time t_{infinite} cannot exist in the temporal series. Actual infinite stands outside of the series, timelessly and abstractly. But here we are talking about what happens in the concrete world which exists in a temporal series. The proponent of KCA is referring to what happens in time in the concrete world when he/she argues that time is finite in the past and that a causal series in a concrete world is likewise finite in the past.[13] If one wants to talk about the timelessly abstract which has no causal powers, which would be irrelevant to the KCA and does not block the conclusion of the argument. In the concrete world finite remains finite. There is a gap between finite and infinite which cannot be transcended.

The objector is claiming that there is a distinction between traversing from present to future and traversing from past to present, and that while it is impossible to arrive at an actual infinite by traversing from present to future, it is possible to arrive at an actual infinite by traversing from past to present. However, if actual infinite is too large to be traversed by a one-after-another process, this should remain the case regardless of whether it is from the past to present or from the present to future. The reason is because the number of elements required to be traversed from an actual infinite past to the present and from the present to an actual infinite future is the same. Thus, the objection fails. It should be noted that my argument for why it fails is not based on the assumption that time is finite, which would be begging the question. Rather it is based on an independent reason concerning the nature of finitude and actual infinite, as well as the nature of a 'one after another' temporal process. Given that my argument is based on this independent reason rather than on the assumption that time is finite, it does not beg the question against an actual infinite past. It should also be noted that the impossibility to traverse an actual infinite is not due to our human inability to conceive this traversal, rather it is due to the nature of an actual infinite, which cannot be traversed by an one-after-another process because an actual infinite is 'too large' to be traversed that way.

The strength of such philosophical arguments against an actual infinite past has been acknowledged in a peer-reviewed scientific paper by leading cosmologists and philosophers of science Ellis, Kirchner, and Stoeger. They write,

Realized infinite sets are not constructible—there is no procedure we can in principle implement to complete such a set—they are simply incompletable. However, if that is the case, then 'infinity' cannot be arrived at, or realized. On the contrary, the concept itself implies its inability to be realized in a real physical setting! This is why, for example, a realized past infinity in time is not considered possible from this standpoint—because it involves an infinite set of completed events or moments. There is no way of constructing such a realized set, or actualising it (Ellis et al. 2004, p. 927).

2.8 Conclusion

The development of the Big Bang theory in the twentieth century has led a number of scientists and philosophers to infer an absolute beginning to all physical things and a divine Cause of these things. While a vocal minority of philosophers such as Adolf Grünbaum and Quentin Smith have claimed that Big Bang cosmology disconfirms theism, I have explained the reasons why many do not find their case persuasive. On the other hand, the realisation that our current understanding of the physics of space-time break down at the beginning of the Big Bang, that we currently do not have a well-established theory of quantum gravity, and that there might have been an earlier universe operating in accordance with quite different physical laws has led many to doubt whether we can infer an absolute beginning to all physical things from the Big Bang. I have argued that this doubt can in principle be addressed by philosophical arguments which (if sound) would lead to conclusions that are true in all possible worlds. I note that Craig has offered two philosophical arguments for thinking that an actual infinite temporal regress is impossible: the argument for the impossibility of concrete actual infinities and the argument for the impossibility of traversing an actual infinite. Critics have raised various objections to these arguments. I do not think these objections are unanswerable, and I have replied to them in this chapter and in various publications.[14] Other creative and powerful ways of advancing these two arguments have also been suggested (e.g. Waters 2013; Koons 2014). Nevertheless, there is a novel way to demonstrate that there is a First Cause of time without even requiring these arguments, and which is therefore immune to the objections which attempt to undercut these arguments.[15] I shall explain this in the next chapter.

Notes

1. Craig explains, 'God's infinity can be taken to mean that God is metaphysically necessary, morally perfect, omnipotent, omniscient, eternal, etc., and that none of these need involve an actual infinite number of things (e.g., "omnipotence is not defined in terms of quanta of power possessed by God or number of actions God can perform but in terms of His ability to actualize states of affairs")' (Craig 2009).
2. For example, an actual infinite number of propositions in the Truth Regress (for any proposition, P, P entails that it is true that P, and the proposition that it is true that P entails that it is true that it is true that P, ad infinitum; see Huemer 2014, p. 88).
3. The other arguments for and against the possibility of extended simples remain inconclusive, and (in my view) are not as compelling as the argument against the possibility of a concrete actual infinite which I discuss below. For a survey of the arguments concerning extended simples, see Sect. 5 of Gilmore (2014).
4. I thank Dr William Lane Craig for this analogy.
5. Peter Lyth claims that my argument conflates number as a number of events or things with number as an abstract entity (Lyth 2014, 85–88). This claim is false, because 'number' is understood in the same sense throughout the argument, i.e. as an abstract entity with no independent causal power (Loke 2017).
6. The problem with an actual infinite temporal regress also cannot be avoided by using surreal numbers or hyperreal numbers. For a summary of details concerning surreal numbers see Oppy (2006, p. 272); for hyperreal numbers see Nowacki (2007, p. 75). While there are different kinds of actual infinities with varying sizes (e.g., the set of real numbers has a higher cardinality than the set of integers), it remains the case that each of these kinds of actual infinities will likewise entail the violation of metaphysical necessities explained in this chapter if it were exemplified in the concrete world, and that it cannot be traversed by a sequential process in the concrete world (see next section).
7. Cf. Aristotle: 'For motion…, although what is continuous contains an infinite number of halves, they are not actual but potential halves (*Physics* 263a25–27)… Therefore to the question whether it is possible to pass through an infinite number of units either of time or of distance we must reply that in a sense it is and in a sense it is not. If the units are actual, it is not possible: if they are potential, it is possible' (*Physics* 263b2–5).

8. See also Aristotle *Physics* 239b5–32; 263a26–b8. Cf. Huemer (2014, pp. 92–3).
9. Likewise the objection that 'if someone runs a pencil along a line from start to finish he/she would have traversed an actual infinite number of points on that line concretely' assumes that that line is composed of an actual infinite number of concrete points, but this assumption can be challenged as noted previously.
10. Consider the type of supertasks consisting of an infinite sequence of actions of the type (a_1, a_2, a_3, … , a_n, …) and thus having the same type of order as the natural order of positive integers: 1, 2, 3, …, *n*, … It is customary to denote this type of order with letter 'ω' and so the related supertasks can be called supertasks of type ω. See Sect. 1.2 of Laraudogoitia (2013).
11. I thank Julian Perlmutter for raising this objection.
12. Note that I stated 'one generation is produced at t_p'; I did not state or assume that there is a total of one generation at t_p, which is false if there are generations before t_p.
13. In answer to the question 'is the one-after-another process selectively chosen for the purpose of showing a finite past?', I would answer that the one-after-another process is chosen because we want to find out where we come from ultimately: I came from my parents, they came from their parents… can this one-by-one process be an actual infinite regress?
14. In addition to my publications cited above, see also Loke (2014a) and Loke (2016b: this paper addresses the objections Morriston raised against Craig in their correspondences concerning eternal future).
15. Moreland and Craig (2003, p. 88) observe that there are at least two kinds of defeaters (1) rebutting defeaters, which directly attack the conclusion. (2) Undercutting defeaters, which attack the reasons offered for the conclusion.

References

Ali, Ahmed Farag, and Saurya Das. 2015. Cosmology from Quantum Potential. *Physics Letters B* 741: 276–279.

Barr, Stephen. 2012. Modern Cosmology and Christian Theology. In *The Blackwell Companion to Science and Christianity*, ed. Alan G. Padgett and J.B. Stump. Chichester: Wiley-Blackwell.

Baum, L., and P.H. Frampton. 2007. Turnaround in Cyclic Cosmology. *Physical Review Letters* 98: 071301, preprint: http://arxiv.org/abs/hep-th/0610213.

Bersanelli, Marco. 2011. Infinity and the Nostalgia of the Stars. In *Infinity: New Research Frontiers*, ed. Michael Heller and Hugh Wood. Cambridge: Cambridge University Press.

Bojowald, M., G. Date, and G.M. Hossain. 2004. The Bianchi IX Model in Loop Quantum Cosmology. *Classical and Quantum Gravity* 21: 3541, preprint: http://arxiv.org/abs/gr-qc/0404039.

Browne, Malcolm. 1978. Clues to the Universe's Origin Expected. *New York Times*, March 12, p. 1, col. 54.

Bussey, Peter. 2013. God as First Cause—A Review of the Kalam Argument. *Science & Christian Belief* 25: 17–35.

Cantor, George. 1915. *Contributions to the Founding of the Theory of Transfinite Numbers*. Trans. and Intro. P.E.B. Jourdain. New York: Dover.

Carroll, Sean, and William Lane Craig. 2014. God and Cosmology: The Existence of God in Light of Contemporary Cosmology. Debate transcript. http://www.reasonablefaith.org/god-and-cosmology-the-existence-of-god-in-light-of-contemporary-cosmology#ixzz4WGdvjBqt. Accessed 20 Jan 2017.

Craig, William Lane. 1994. Creation and Big Bang Cosmology. *Philosophia Naturalis* 31: 217–224.

Craig, William Lane. 2000a. *The Tensed Theory of Time: A Critical Examination*, Synthese Library, vol. 293. Dordrecht: Kluwer Academic.

Craig, William Lane. 2000b. *The Tenseless Theory of Time: A Critical Examination*, Synthese Library, vol. 294. Dordrecht: Kluwer Academic.

Craig, William Lane. 2008. Review of *Philosophical Perspectives on Infinity*, by Graham Oppy. *Philosophia Christi* 10: 201–208.

Craig, William Lane. 2009. Q&A #106: Is God Actually Infinite? Available at http://www.reasonablefaith.org/is-god-actually-infinite. Accessed 4 July 2013.

Craig, William Lane. 2011. Graham Oppy on the Kalam Cosmological Argument. *International Philosophical Quarterly* 51: 303–330.

Craig, William Lane. 2013. The Kalam Argument. In *Debating Christian Theism*, ed. J.P. Moreland, Chad V. Meister, and Khaldoun A. Sweis. Oxford: Oxford University Press.

Craig, William Lane, and James Sinclair. 2009. The Kalam Cosmological Argument. In *The Blackwell Companion to Natural Theology*, ed. William Lane Craig and J.P. Moreland. Chichester: Wiley-Blackwell.

Craig, William Lane, and James Sinclair. 2012. On Non-Singular Space-Times and the Beginning of the Universe. In *Scientific Approaches to the Philosophy of Religion*, ed. Yujin Nagasawa. New York: Palgrave Macmillan.

Dedekind, Richard. 1963. The Nature and Meaning of Numbers. In *Essays on the Theory of Numbers*, ed. Richard Dedekind, trans. W.W. Beman, 29–115. New York: Dover.

East, James. 2013. Infinity Minus Infinity. *Faith and Philosophy* 30: 429–433.

Ellis, George. 2007. Issues in the Philosophy of Cosmology. In *Philosophy of Physics*, ed. J. Butterfield and J. Earman. Amsterdam: Elsevier.

Ellis, George, U. Kirchner, and W.R. Stoeger. 2004. Multiverses and Physical Cosmology. *Monthly Notices of the Royal Astronomical Society* 347: 921–936. http://arXiv.org/abs/astro-ph/0305292. Accessed 11 July 2008.

Ellis, George, and R. Maartens. 2004. The Emergent Universe: Inflationary Cosmology with No Singularity. *Classical and Quantum Gravity* 21: 223, preprint: http://arxiv.org/abs/gr-qc/0211082.

Feferman, Solomon. 1998. *In the Light of Logic*. Oxford: Oxford University Press.

Fine, K. 1994. Essence and Modality. *Philosophical Perspectives* 8: 1–16.

Ford, Kenneth. 2011. *101 Quantum Questions: What You Need to Know About the World You Can't See*. Cambridge, MA: Harvard University Press.

Gambini, Rodolfo, and Jorge Pullin. 2013. Loop Quantization of the Schwarzschild Black Hole. *Physical Review Letters* 110: 211301.

Gendler, Tamar, and John Hawthorne (eds.). 2002. *Conceivability and Possibility*. Oxford: Oxford University Press.

Gilmore, Cody. 2014. Location and Mereology. In *The Stanford Encyclopedia of Philosophy* (Fall 2014 Edition), ed. Edward N. Zalta. http://plato.stanford.edu/archives/fall2014/entries/location-mereology/.

Grünbaum, Adolf. 1989. The Pseudo-Problem of Creation in Physical Cosmology. *Philosophy of Science* 56: 373–394.

Grünbaum, Adolf. 1991. Creation as a Pseudo-Explanation in Current Physical Cosmology. *Erkenntnis* 35: 233–254.

Grünbaum, Adolf. 1994. Some Comments on William Craig's 'Creation and Big Bang Cosmology'. *Philosophia Naturalis* 31: 225–236.

Guminski, Arnold. 2002. The Kalam Cosmological Argument: The Question of the Metaphysical Possibility of an Infinite Set of Real Entities. *Philo* 5: 196–215. http://www.infidels.org/library/modern/arnold_guminski/kalam.html.

Halvorson, Hans and Helge Kragh. 2011. Cosmology and Theology. In *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, Winter 2011 edition. http://plato.stanford.edu/archives/win2011/entries/cosmology-theology/.

Hedrick, Landon. 2014. Heartbreak at Hilbert's Hotel. *Religious Studies* 50: 27–46.

Hilbert, David. 1964. On the Infinite. In *Philosophy of Mathematics*, ed. P. Benacerraf and H. Putnam. Englewood Cliffs, NJ: Prentice-Hall.

Huemer, Michael. 2014. Virtue and Vice Among the Infinite. In *Ad Infinitum*, ed. John Turri and Peter Klein. Oxford: Oxford University Press.

Jastrow, Robert. 2000. *God and the Astronomers*, 2nd ed. New York: W.W. Norton.

Koons, Robert. 2014. A New Kalam Argument: Revenge of the Grim Reaper. *Noûs* 48: 256–267.

Krauss, Lawrence, and William Lane Craig. 2013. Life, the Universe, and Nothing (III): Is it Reasonable to Believe There is a God? http://www.reasonablefaith.org/life-the-universe-and-nothing-is-it-reasonable-to-believe-there-is-a-go#ixzz4WHegKUWq. Accessed 20 Jan 2017.

Laraudogoitia, Jon Pérez. 2013. Supertasks. In *The Stanford Encyclopedia of Philosophy* (Fall 2013 Edition), ed. Edward N. Zalta. http://plato.stanford.edu/archives/fall2013/entries/spacetime-supertasks/.

Le Poidevin, Robin. 2003. *Travels in Four Dimensions: The Enigmas of Space and Time*. Oxford: Oxford University Press.

Linde, Andrei. 1994. The Self-Reproducing Inflationary Universe. *Scientific American* 271: 48–55.

Loke, Andrew. 2012. Is an Infinite Temporal Regress of Events Possible? *Think* 11: 105–122.

Loke, Andrew. 2014a. A Modified Philosophical Argument for a Beginning of the Universe. *Think* 13: 71–83.

Loke, Andrew. 2014b. No Heartbreak at Hilbert's Hotel: A Reply to Landon Hedrick. *Religious Studies* 50: 47–50.

Loke, Andrew. 2016a. On Finitism and the Beginning of the Universe: A Reply to Stephen Puryear. *Australasian Journal of Philosophy* 94: 591–595.

Loke, Andrew. 2016b. On Beginningless Past, Endless Future, God, and Singing Angels: An Assessment of the Morriston-Craig Dialogue. *Neue Zeitschrift für Systematische Theologie und Religionsphilosophie* 58: 57–66. doi:10.1515/nzsth-2016-0004.

Loke, Andrew. 2016c. On the Infinite God Objection: A Reply to Jacobus Erasmus and Anné Hendrik Verhoef. *Sophia* 55: 263–272. doi:10.1007/s11841-016-0539-8.

Loke, Andrew. 2017. A Reply to Peter Lyth on Whether an Infinite Temporal Regress of Events is Possible. *Think* 16: 77–81.

Lyth, Peter. 2014. A Response to Loke's 'is an infinite temporal regress of events possible?'. *Think* 13: 85–88.

Maddy, Penelope. 1997. *Naturalism in Mathematics*. Oxford: Clarendon Press.

Monton, Bradley. 2010. Design Inferences in an Infinite Universe. In *Oxford Studies in Philosophy of Religion*, vol. II. Oxford: Oxford University Press.

Moore, A.W. 2001. *The Infinite*. London: Routledge.

Moreland, J.P. 2003. A Response to a Platonistic and to a Set-Theoretic Objection to the Kalām Cosmological Argument. *Religious Studies* 39: 379.

Moreland, J.P., and William Lane Craig. 2003. *Philosophical Foundations for a Christian Worldview*. Downers Grove: InterVarsity Press.

Morriston, Wes. 2002. Craig on the Actual Infinite. *Religious Studies* 38: 147–166.

Morriston, Wes. 2003. Must Metaphysical Time Have a Beginning? *Faith and Philosophy* 20: 296–301.

Morriston, Wes. 2013. Doubts About the Kalam Argument. In *Debating Christian Theism*, ed. J.P. Moreland, Chad V. Meister, and Khaldoun A. Sweis. Oxford: Oxford University Press.

Nowacki, Mark. 2007. *The Kalam Cosmological Argument for God*. Amherst, NY: Prometheus Books.

Oppy, Graham. 2006. *Philosophical Perspectives on Infinity*. New York: Cambridge University Press.

Philipse, Herman. 2012. *God in the Age of Science? A Critique of Religious Reason*. Oxford: Oxford University Press.

Pitts, Brian. 2008. Why the Big Bang Singularity Does Not Help the Kalām Cosmological Argument for Theism. *The British Journal for the Philosophy of Science* 59: 675–708.

Poplawski, N.J. 2010. Radial Motion into an Einstein–Rosen Bridge. *Physics Letters B* 687: 110–113.

Puryear, Stephen. 2014. Finitism and the Beginning of the Universe. *Australasian Journal of Philosophy* 92: 619–629.

Puryear, Stephen. 2016. Finitism, Divisibilty, and the Beginning of the Universe: Replies to Loke and Dumsday. *Australasian Journal of Philosophy* 94: 808–813. doi:10.1080/00048402.2016.1194443.

Reichenbach, Bruce. 2016. Cosmological Argument. In *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, Winter 2016 edition. https://plato.stanford.edu/archives/win2016/entries/cosmological-argument/.

Russell, Bertrand. 1969. *History of Western Philosophy and Its Connection with Political and Social Circumstances from the Earliest Times to the Present Day*. London: Allen and Unwin.

Sorabji, R. 1983. *Time, Creation and the Continuum*. Ithaca, NY: Cornell University Press.

Smith, Quentin, and Nathan Oaklander. 1995. *Time, Change and Freedom: An Introduction to Metaphysics*. London: Routledge.

Sobel, Jordan. 2004. *Logic and Theism: Arguments for and Against Beliefs in God*. Cambridge: Cambridge University Press.

Steinhardt, P., and N. Turok. 2005. The Cyclic Model Simplified. *New Astronomy Reviews* 49: 43–57, preprint: http://arxiv.org/abs/astro-ph/0404480.

Stoeger, William. 2010. God, Physics and the Big Bang. In *The Cambridge Companion to Science and Religion*, ed. Peter Harrison. Cambridge: Cambridge University Press.

Swinburne, Richard. 2004. *The Existence of God*, 2nd ed. Oxford: Clarendon.

Van Bendegem, Jean Paul. 2011. The Possibility of Discrete Time. In *The Oxford Handbook of Philosophy of Time*, ed. Craig Callender. Oxford: Oxford University Press.

Veneziano, G., and M. Gasperini. 2003. The Pre Big Bang Scenario in String Cosmology. *Physics Reports* 373: 1–212.

Vilenkin, Alexander. 1982. Creation of Universes from Nothing. *Physics Letters* B117: 25.

Wall, Aron. 2014a. Did the Universe Begin? IV: Quantum Eternity Theorem. http://www.wall.org/~aron/blog/did-the-universe-begin-iv-quantum-eternity-theorem/. Accessed 20 Jan 2017.

Wall, Aron. 2014b. Did the Universe Begin? X: Recapitulation. http://www.wall.org/~aron/blog/did-the-universe-begin-x-recap/. Accessed 20 Jan 2017.

Waters, Ben. 2013. Methuselah's Diary and the Finitude of the Past. *Philosophia Christi* 15: 463–469.

Weinberg, Steven. 1977. *The First Three Minutes: A Modern View of the Origin of the Universe*. London: Trinity Press.

Wolchover, Natalie. 2013. To Settle Infinity Dispute, a New Law of Logic. https://www.simonsfoundation.org/quanta/20131126-to-settle-infinity-question-a-new-law-of-logic/. Accessed 20 Jan 2017.

Wu, Y.L. 2003. Symmetry Principle Preserving and Infinity Free Regularization and Renormalization of Quantum Field Theories and the Mass Gap. *International Journal of Modern Physics A* 18: 5363–5420 [arXiv:hep-th/0209021].

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http://www.springer.com/978-3-319-57546-9

God and Ultimate Origins
A Novel Cosmological Argument
Loke, A.T.E.
2017, XV, 200 p. 3 illus., Hardcover
ISBN: 978-3-319-57546-9