# CRITICAL DISCUSSION OF STEPHEN HAWKING'S BIG BANG ARGUMENT AGAINST GOD

**Jan Dejnožka***

*Union College, Department of Philosophy, Lamont House 106, Schenectady, New York, 12308, U.S.A.*

(Received 22 May 2022, revised 26 July 2022)

## Abstract

This paper is a critique of Stephen Hawking's very popular Big Bang argument against the existence of God in his book, 'Brief Answers to the Big Questions' (2018). It is a discussion of a single argument in a single text in a single author, in the manner of analytic philosophy. Many writers discuss whether Big Bang theory implies that God could not have created the world, such as William Lane Craig, Quentin Smith, Richard Swinburne, Daniel Linford, and Daniel Saudek; but I mention them only to set them aside. Instead, I shall simply use Hawking to criticize his own argument. I hope to show that in his more considered views in other texts, Hawking implies at least seven criticisms of his own argument. If I am right, then far from objecting to my critique, Hawking himself would seem to agree with it. Most of the paper is on quantum physics and some is on general relativity. The next to last section is on the proper scope of 'ex nihilo nihil fit'.

*Keywords:* Stephen Hawking, God, Big Bang theory, Quantum physics, General relativity theory

## 1. Hawking's argument

Hawking states the argument as follows: "Since we know the Universe itself was once very small - perhaps smaller than a proton - this means something quite remarkable. It means the Universe itself, in all its mind-boggling vastness and complexity, *could* simply have popped into existence without violating the known laws of Nature.... But here's the crucial bit. The laws of Nature itself tell us that not only *could* the Universe have popped into existence without any assistance, like a proton [in Quantum physics], and have required nothing in terms of energy [per the zero sum balance theory of positive and negative energy; see the quote on Guth below], but also that it is *possible* that nothing caused the Big Bang. Nothing. The explanation lies back with the theories of Einstein, and his insights into how space and time in the universe are fundamentally intertwined. Something very wonderful happened to time at the instant of the Big Bang. Time itself began.... When people ask me if God created

* E-mail: dejnozka@umich.edu

the universe, I tell them that the question itself makes no sense. Time didn't exist before the Big Bang so there is no time for God to make the universe in. It's like asking directions to the edge of the Earth - the Earth is a sphere that doesn't have an edge, so looking for it is a futile exercise." ([1], my emphasis)

Hawking's argument seems to be that the Universe *could* have simply popped into existence at the quantum level, and then expanded in the Big Bang. Therefore the Universe "doesn't *need* to be set in motion by some god" ([2], my emphasis), though of course it still *could* have been created by God. One would then presumably use Ockham's razor to eliminate God as unnecessary. Hawking's argument in the second two quoted paragraphs is quite different. It is that "Time itself began" with the Big Bang, therefore "there is [or was] no time for God to" create the Universe before the Universe existed. Here the tenor of the argument is that God could *not* have created the Universe. I shall call the conjunction of these two sub-arguments Hawking's Big Bang argument against God, or more simply his Big Bang argument.

Einstein famously called quantum entanglements 'spooky action at a distance'. And not only can quanta pop in and out of existence, but they can travel faster than the speed of light, go forwards and backwards in time, and even affect the past [1, p. 154-155; 2, p. 82]. (It is not only quanta that can travel faster than the speed of light. The rapid expansion of the whole Universe after the Big Bang was faster than the speed of light too [2, p. 129, 130].) And whatever they do is not determined, but only probable at best, from among infinitely many possible quantum histories of the world.

There is determinism in the mathematical language of Quantum physics, but it is not classical Laplacean determinism. The Mathematics is not used to describe the real physical world as it might be in itself, but only in terms of our observations of it [3]. We can no longer describe both the position and the speed (or momentum) of a particle, since the more accurate we are about the one, the less accurate we are about the other. Instead, Quantum physics describes waves which are *combinations* of positions and speeds, and it is these waves that are completely determined [3, p. 188-189].

Thus "Quantum physics.... leads us to accept a new form of determinism" in which it is not events but their probabilities which are determined [2, p. 72]. What makes this a new and different form of determinism is that paradoxically, "Probabilities in quantum theories... reflect a fundamental randomness in Nature" [2, p. 74]. In fact, that is precisely why the new laws are probability laws. That is all they can be, if Nature is really random at bottom. Here too, the 'why' question can be raised. It can *always* be raised about physical laws, since they can only describe the 'how', and can only explain the why in the limited sense of describing the how. Why did the match light? Because it was struck, and assuming certain background conditions, matches always light when they are struck. Even if we reject David Hume's theory of physical law as mere description and admit real physical causation, we can still ask why there is real physical causation.

That Quantum physics is a new form of determinism is old news. Werner Heisenberg called quantum physics 'deterministic' long ago and said, "The probability function [of Quantum physics] obeys an equation [and] is completely determined by the quantum mechanical equation.... [But] observation breaks the determined continuity of the probability function by changing our knowledge of the [physical thing]." [4]

The change to an observed physical thing is due to the fact that in order for us to visually observe it, photons have to hit it; and the consequences of the hits "cannot be predicted.... Instead, [Quantum physics] predicts a number of different possible outcomes and tells us how likely each of these is." [3, p. 56-58].

The uncertainty principle is simply that "we only know some *combination* of position and speed of a particle" ([1, p. 53], my emphasis). Thus in Quantum physics, all we have is "a *quantum state* [or wave function], which [is] a *combination* of position and velocity" ([3, p. 57], my emphasis).

Thus Hawking's argument (really the first sub-argument) might be called the case for the possible spooky origin of the world. The main choice Hawking is placing before us in his argument against God, then, is between the divine or the spooky origin of the world. Of course, there are other options, such as that the world always was, stretching infinitely back in time [3, p. 8]. Or as Einstein's general relativity theory has it, the real physical world and its physical laws are timeless, since time occurs only in relative frames of observational reference; and physical laws, such as $E = mc^2$, are invariant across all frames of reference. The relativity of both space and time to the observer is what Einstein's general relativity theory is most famous for [5]. On physical reality as what is invariant across frames of reference in general relativity theory, see Margenau [6], Ushenko [7] and Minkowski [8]. If Einstein is right that there is no such thing as time in physical reality, then not only was there no time *before* the Big Bang, but there was no time *during* or *after* the Big Bang either. The Big Bang would be in the past only relative to our framework as observers. And God could have created the universe at a time before the Universe existed relative to God's framework as an observer sub specie temporalis.

## 2. A counterexample

Einstein is famous for his 'thought-experiments', and perhaps we might offer one of our own. Imagine that there are some observers who are shielded from the Big Bang by special laws that apply only to a transparent sphere containing the local space-time twenty feet around them. These special laws allow them to live through the Big Bang in safety and comfort from within their sphere. They might not be able to observe the Big Bang itself for theoretical reasons. But relative to their own local space and time in the sphere, they can look out through their sphere, observing the empty universe before the Big Bang, and the stars and planets after the Big Bang. We can even imagine that they have a scientific laboratory with various clocks, telescopes, and search lights. Perhaps 'an eon is but a day in the sight' of these observers. The special laws let them live long and their equipment function within the sphere. The laws need not even be special. If the sphere is composed of a new element, then the laws would be just as universal as the laws that govern any other element. We may call this new element 'entropium'. There are plain analogies of entropium to actual protective coverings, such as sealed jars and Faraday pouches. (If you wrap up your cell phone in enough aluminium foil, then no one can call you or find you; and that is a Faraday pouch.) Everything in this example is logically possible, since all physical laws are logically contingent. And the example is logically possible only if time existed before the Big Bang - and observer - measurable time at that. So God would have had plenty of time to create the Big Bang. In fact, even the observers would have had the time! This refutes the second sub-argument.

It might be objected that our thought-experiment is wholly imaginary. One reply would be that the same might be said of Einstein's thought-experiments of traveling close to, at, or faster than the speed of light, and of travelling backwards in time. But the real reply is that the objection misses the whole point of the counterexample. Thought-experiments may start from empirical facts, but they are all about logical reasoning. That is why they are thought-experiments and not empirical experiments. And logical possibility is all we need to show that the second sub-argument is wrong. That the Universe, or for that matter, time, is finite but without a beginning, like a sphere without an edge, has nothing to do with it. That is simply irrelevant. For in the sphere metaphor, the observers in my counterexample would be *on* the finite sphere's surface, meaning *in* finite time, and not beyond or outside it.

Actually, the entropium counterexample is far more than just a mere logical possibility. It is also a real physical possibility, and even very slightly probable. On the multiverse theory of Quantum physics, the multiverse consists of indefinitely many universes each of which obeys its own physical laws. And indefinitely many of these universes would physically contain entropium. Hawking says, "M-theory predicts that a great many universes were created out of nothing.... Each universe has many possible histories and many possible states at later times...." [2, p. 8-9]. Hawking says that on Richard Feynman's sum over histories method for calculating quantum probabilities from all possible histories of quanta, "[T]he Universe appeared *spontaneously starting off in every possible way*. *Most* of these correspond to other universes [that lasted at least a moment]. While some of these universes are very similar to ours, most are very different. They aren't just different in details,... but rather *they differ even in their apparent laws of nature. In fact, many universes exist with different sets of physical laws*. Some people make a great mystery of this idea, sometimes called the multiverse concept, but these [universes] are just different expressions of the Feynman sum over histories." ([2, p. 136], my emphasis)

Thus on Feynman's sum over histories method, on which quanta travel in all possible directions and form all kinds of different universes with all kinds of different physical laws, it is not only physically possible, but even very slightly probable that entropium exists in *our* Universe, because it *does* exist in indefinitely many universes within the multiverse. Of course, the probability is extremely slight. Hawking says, "Feynman's approach to understanding how things work is to assign to each possible history [or possible universe] a particular probability, and then use this idea to make predictions. It works spectacularly well to predict the future. So we presume it works to retrodict the past too" [1, p. 54]. And retrodiction is needed if things (quarks and even rocket ships) travel backwards in time in some histories.

In fact, "An important implication of the top-down approach [of figuring out the Universe's origin from how it is now] is that the apparent laws of Nature depend on the history of the Universe.... [T]op-down cosmology *dictates* that the apparent laws of Nature are different for different histories." ([2, p. 140], my emphasis)

Thus top-down cosmology *dictates* that entropium exists in some universes within the multiverse.

Hawking says, "In some histories space-time will be so warped that objects like rockets will be able to travel into their pasts. But each history is complete and self-contained, describing not only the curved space-time but also the objects in it. So a rocket cannot transfer to another alternative history when it comes round again. It is still in the same history which has to be consistent." [1, p. 140]

Thus the science fiction stories are wrong. There is no such thing as interacting universes within the multiverse. To interact is to be in the same universe. People in different histories, or in different universes, cannot see each other or talk with each other, much less visit or interact with each other. Thus, at most, people can only have different *de dicto* 'counterpart' versions of themselves in some of the other universes, or alternatively, different *de re* objectual ways they might have been. But the *de dicto-de re* issue takes us out of science and into the philosophical interpretation of possible worlds logic; see Saul A. Kripke [9] for a classic discussion.

Even on the alternative-histories theory, as opposed to the consistent-histories theory, to visit another history is to start a new history [1, p. 139-140]. Thus even on that theory, there is no contact or interaction with other histories, and thus no contact or interaction with other universes, since they all have their own sets of histories. See the rocket quote just above.

This is a bit like Leibniz's logically possible worlds. Everything is interdefined in each possible world. Thus by definition, to 'visit' or 'communicate' with a different possible world is to change that world into another possible world. But the multiverse is empirical physics, while logically possible worlds are philosophy.

Hawking says "the multiverse idea... is a consequence of the no-boundary condition as well as many other theories of modern cosmology" [2, p. 164]. The no-boundary condition is briefly explained in a text quoted below.

## 3. Hawking's seven implicit criticisms of his own Big Bang argument

It puzzles me why Hawking does not present his Big Bang argument as carefully as he discusses the Big Bang itself. I am not sure it is because his book is aimed at a popular audience. It is all the more puzzling because Hawking presupposes in his Big Bang argument that causes occur earlier than their effects, and he is well aware that this has been outdated physics for almost a century.

In fact, Hawking expresses more considered views in other texts. And I find that at least seven implicit criticisms of his Big Bang argument emerge from those texts.

First, Hawking says: "[E]ven if there *were* events before the Big Bang, one could not *use* them to determine what would happen afterward, because predictability would break down at the Big Bang. Correspondingly, if, as is the case, we know only what has happened *since* the Big Bang, *we could not determine* what has happened *beforehand*. [Thus a]s far as we are concerned, events before the Big Bang can have no [predictable] consequences, so they should not form part of a scientific model of the Universe. We should therefore cut them out of the model and *say* that time had a beginning at the Big Bang." ([3, p. 49], my emphasis)

In other words, Hawking openly admits there *could* have been physical events before the Big Bang, and the only problem is that we cannot *know* or *predict* (or retrodict) anything about them, at least not in the present state of scientific understanding. And as we all know, the verificationist or operational theory of meaning is self-defeating: it cannot even observationally confirm or disconfirm itself as meaningful. As they say, "it takes but one sordid fact [disconfirming observation, counterexample, thought-experiment] to slay a beautiful theory". And here the theory itself does the job for us.

Hawking can still use Ockham's razor to shave God. As we saw, Hawking says "the Universe... could simply have popped into existence" [1]. But Hawking doubtless agrees with Einstein's view that simplicity must be weighed against adequate explanation [10]. And Einstein finds that that "Science without religion is lame" [11] (see also [12, 13]). Einstein finds that we cannot fully explain the harmony of nature without admitting at least an impersonal God [11, 14, 15]. Hence Einstein would not use the razor to shave God, since he finds that without God, we do not have an adequate explanation of nature. But here Hawking is not using Ockham's razor to shave any events before the Big Bang. The razor counsels us not to admit any entities that are not *necessary* for an adequate scientific or other sort of explanation. But Hawking is saying that it is not even *possible* for any events before the Big Bang to have knowable or predictable consequences, at least not in our present state of scientific understanding.

Second, as we saw earlier, Hawking admits that causes do not always occur earlier than their effects. He says that on Richard Feynman's sum over histories theory [2, p. 75-80]. That is why quanta go forward and backward in time [1, p. 154-155].

Hawking does not say so, but I think the implication is clear: if we consider *every* possible path of *every* quantum, then *every* quantum goes backwards in time before the Big Bang. And in some histories, there were indefinitely many quantum events before the Big Bang. (This also concerns what I call the primordial quantum soup, discussed below.) And if any humble little quantum can go back and affect the past, including the Big Bang itself, then why cannot the almighty God?

Third, even we ordinary humans causally change the past simply by observing events in the present. Hawking and Leonard Mlodinow say that in Quantum physics, "The fact that the past takes no definite form means that observations you make on a system in the present affect its past" [2, p. 82]. Hawking and Mlodinow say that the Feynman sum over histories "leads to a radically different view of cosmology, *and the relation between cause and effect.* The histories that contribute to the Feynman sum don't have an independent existence, but depend on what is being measured. *We create history by our observation, rather than history creating us.* The idea that the Universe does not have a unique observer-independent history might.... sound like science fiction, but it isn't." ([2, p. 139-140], my emphasis)

And if we mere humans can change the past, then why cannot God - simply by a mighty act of observation in the present, or even in the future?

Fourth, Hawking admits that even if the Universe just popped into existence as a merely probably (or improbable) quantum event, it still emerged from a sort of primordial bubbling soup (my term) of quanta, a sort of quantum plenum of all possible quantum events. Now, how could the Universe emerge from a primordial quantum soup, unless the soup existed before the Universe did? And if the quantum soup existed before the universe did, then why could not God?

Hawking says that on Feynman's sum over histories method, "Our picture of the spontaneous quantum creation of the Universe is then a bit like the formation of bubbles of steam in boiling water. Many tiny [soup] bubbles appear, then disappear again. These represent mini-universes that expand but collapse again while still of microscopic size. They represent possible alternative universes, but they... do not last long enough to develop galaxies and stars, let alone intelligent life. A few of the little bubbles, however, will grow large enough so that they will be safe from collapse. They will continue to expand at an ever-increasing rate and will form the bubbles of steam we are able to see. These correspond to universes that start off expanding at an ever-increasing rate - in other words, universes in a state of inflation." [2, p. 136-137]

Again, if a primordial quantum soup existed before the Universe did, then why could not God? And it is very hard for me to see how the Universe could emerge from the soup unless the soup existed first.

Even empty space is always bubbling over with zero-sum quantum events [1, p. 135; 2, p. 113, 137].

Fifth, Hawking says that the Big Bang was not even the origin of the Universe: “[I]t is wrong to take the Big Bang literally, that is, to think of Einstein’s theory as providing a true picture of the *origin* of the Universe. That is because general relativity predicts there to be a point in time at which the temperature, density, and curvature of the Universe are all infinite, a situation mathematicians call a singularity. To a physicist this means that Einstein’s theory breaks down at that point and therefore cannot be used to predict how the universe began.... So... it is not correct to carry the Big Bang picture all the way back to the beginning.” ([2, p. 128-129], Hawking’s emphasis)

In fact, on the no-boundary condition proposal, offered as part of the quantum theory of gravity, “[t]here would be no singularities at which the laws of science broke down” [3, p. 141]. Hawking still accepts that there was a Big Bang and that it was “very small - perhaps smaller than a proton” [1]. He is only denying that the Big Bang was an infinitesimal singularity as predicted by general relativity. For general relativity breaks down in the Big Bang, and Quantum physics applies. And that is only to be expected, since general relativity is for big regions of space-time, and Quantum physics is for events that are “perhaps smaller than a proton” [1, p. 34; 3, p. 63]. In fact, “we do know that the origin of the Universe was a quantum event” [2, p. 131].

Of course, this fifth implicit correction to his Big Bang argument (the first sub-argument) is irrelevant to the success of the argument. Regardless of whether the origin of the Universe was an infinitesimal singularity or a finite-sized quantum event, Hawking can still argue that the origin of the Universe can be explained by physical laws alone. Nonetheless, this is still a correction to his presentation of the argument. And ironically, waiving the quantum soup, this is the very same sort of creation out of nothing, falsifying the old precept *ex nihilo nihil fit* (out of nothing, nothing comes) that people criticize so much if God is thought to do it. But if the physical universe can create itself out of nothing, then why cannot God create the Universe out of nothing?

Hawking’s sixth implicit correction to his Big Bang argument is very simple. Namely, Heisenberg’s uncertainty principle ultimately applies to everything in science. Hawking says, “In effect, we have redefined the task of science to be the discovery of laws that will enable us to predict events up to the limits set by the uncertainty principle” [3, p. 189]. Thus the uncertainty principle applies to Science’s ruling out God as well. That is, the uncertainty principle itself makes it uncertain whether God could have created the world, no matter what science has to say about the Big Bang or even the primordial quantum soup.

Why was there a quantum soup at all? Hawking says, “The answer is that, in quantum theory, particles can be created out of energy in the form of particle/antiparticle pairs. [Thus] the total energy of the Universe is exactly zero [since the positive energy of the particles and the negative energy of the antiparticles cancel each other out].... As [Alan] Guth has remarked, '[T]he Universe is the ultimate free lunch'." [3, p. 133-134]

Hawking grants that God might have been behind all this: "These laws may have been originally been decreed by God, but it appears that he has since left the Universe to evolve according to them and does not now intervene in it" [3, p. 126].

But Hawking says that there is no need to postulate God: "[T]he quantum theory of gravity has opened up a new possibility, in which there would be no boundary to space-time and so there would be no need to specify the behaviour at the boundary. There would be no singularities at which the laws of science broke down, and no edge of space-time at which one would *have* to appeal to God or some new law to set the boundary conditions for space-time. One could say: 'The boundary condition of the universe is that it has no boundary'. The Universe would be completely self-contained and not affected by anything outside itself. It would be neither created nor destroyed. It would just BE." ([3, p. 141], my emphasis)

As we saw in his Big Bang second sub-argument at the beginning of this paper, Hawking compares such a world to the surface of a finite sphere [1; 3, p. 140-141]. But Hawking cautions us that "I'd like to emphasize that this idea that time and space should be finite 'without boundary' is just a *proposal*: it cannot be deduced from some other principle" ([3, p. 141], Hawking's emphasis). Thus the question of God remains open, and Hawking's Big Bang argument is nothing like the knockout punch it seems to be in its second sub-argument.

The seventh and last implicit criticism concerns the direction of time itself. Even if we suppose that all causes are earlier than their effects (which is not at all true in Quantum physics), the direction of time itself would be reversed if the second law of Thermodynamics were reversed, which it is in many universes with different laws within the multiverse, and also in the many contracting universes within the multiverse. The direction of time will be reversed even in our own Universe, if the present stage of expansion is followed by a period of contraction. And either of those options (Universe with reversed second law of Thermodynamics, Universe in contraction) would make all causes that are or that would otherwise be earlier than their effects into causes that are *later* than their effects, in virtue of reversing the direction of time itself. In fact, within a later period of contraction, where everything is running backwards, even the 'earlier' period of expansion would be in the past. It is only within a present period of expansion that a later period of contraction would be later.

The laws of Physics are indifferent to the direction of time. In general relativity theory, the laws must be invariant across all spatio-temporal frameworks, including any frameworks where events seem to be going backwards. In fact, a multiple-variable law like $E = mc^2$ makes no reference to time in the first place. If we replace either variable, i.e. E or m (of course, c is a constant, the speed of light) with a constant, then the value of the other variable can be calculated, and it will not matter what the time is. The only exceptions are that general relativity breaks down for any singularities (infinitesimal points with infinite density; again, on the no-boundary theory, there are no singularities), any quantum-size Big Bangs or other events of sufficiently huge density (notably, black holes), and any rapid expansions, since they are faster than the speed of light. (I use the plurals 'Big Bangs' and 'rapid expansions' so as to include Penrose's and any other cyclic theories of repeated Big Bangs.) But the main thing is that "The laws of Science do not distinguish between the past and future" [3, p. 148]. And importantly for us, "the laws of Science do not distinguish between the forward and backward directions of time" [3, p. 156]. But we do distinguish these directions in real life, and we do know when films are running things backwards [3, p. 148]. Hawking asks, "Where does this difference between the past and future come from? Why do we remember the past but not the future?" [3, p. 148]. I assume he does not simply *define* memory as always being of the past, precisely because what is the past depends on the direction of time. But I suggest that past, future, and direction of time are interdefinable.

Hawking then distinguishes three arrows of time, where "an arrow of time [is] something that distinguishes the past from the future, giving a direction to time" [3, p. 149]. I would call them observable measures of time. These are: the increase of entropy, called the thermodynamic arrow; our psychological or inner sense of time, including memory, called the psychological arrow; and the expansion of the Universe (at least during the present expansion phase of the Universe), called the cosmological arrow [3, p. 149]. In our present Universe, "all three arrows point in the same direction" [3, p. 149]. I will skip the details here [3, p. 147-157]. Importantly for us, Hawking says: "[I]f God had decided that.... disorder would decrease with time[, y]ou would see broken cups gathering themselves together and jumping back onto the table. I shall argue that [any observers in such a universe] would have a psychological arrow of time that was backward. That is, they would remember events in the future, and not remember events in their past." [3, p. 150]

I will skip explaining his argument [3, p. 151-152]. The main thing for us is that if time itself is reversed, or more precisely, if the thermodynamic and psychological arrows are reversed - or even better, if all three arrows are reversed - then the temporal order of cause and effect is reversed as well, since everything is going backwards. Of course, a contraction phase need not necessarily be an exact mirror reversal of the previous ('previous') expansion phase [3, p. 154-155]. Things might contract differently from how they expanded. But that is irrelevant to my point that the temporal order of cause and effect would be reversed. I imagine this also means that any quantum causes that had been *later* than their effects in the expansion phase would become *earlier* than their effects in the contraction phase, since their direction would be reversed relative to, or looking back at them from, the contraction phase. But I think that is for quantum physicists to say, not philosophers like me. But logic does seem to dictate that any simultaneous causes and effects must remain simultaneous, with the caveat that events that appear simultaneous to one observer in one frame of reference will not appear simultaneous to other observers in other frames of reference in General relativity theory.

All this is very odd to our ordinary understanding of time, which is still Newtonian. That is, we still think of time as an observation-independent entity with a single, eternal, and essential direction. But Cosmology is beyond that now. Whether the fact that the Riemannian space of Einstein and the Euclidean space of Newton each can be modelled in terms of the other relieves the tension or only compounds it is beyond the scope of this paper. Of course, Newton deems time to be unobservable in itself, while Einstein requires it to be measurable and in that sense observable. Again, the verificationist/operational theory of meaning condemns itself as meaningless, since no observation can confirm or disconfirm it.

## 4. Hawking's more considered conclusion about God

Hawking's Big Bang argument in the text I quoted at the beginning of this paper is far from being his only text on point. In fact, he and Leonard Mlodinow wrote a whole book about whether God created the Universe, called *The Grand Design* [2]. And at the end of his first book, *A Brief History of Time* [3], he sounds for all the world like he is raising the basic 'why' question of classical theism about his own account. He says, "What is there that breathes fire into the equations and makes a universe for them to describe? The usual approach of science of constructing a mathematical model cannot answer the questions of why there should be a universe for the model to describe. Why does the Universe go to all the bother of existing? Is the unified theory so compelling that it brings about its own existence?.... Up to now, most scientists have been too occupied with the development of new theories that describe *what* the Universe is to ask the question *why*. On the other hand, the people whose business it is to ask *why*, the philosophers, have not been able to keep up with the advance of scientific theories." ([3, p. 190], Hawking's emphasis)

Hawking is surely right to say that the classical theist question of why the Universe exists at all, even as modern Cosmology describes its origin, still can and ought to be raised. Even if the universe is physically self-generating, why is *that* the case? Why was there a quantum soup for it to bubble up from even by chance? Why are the laws of Physics the way they are?

Hawking and Mlodinow seem to go to the opposite extreme near the end of *The Grand Design.* They say, "Because there is a law like gravity, the universe can and will create itself from nothing.... Spontaneous creation is the reason there is something rather than nothing, why the Universe exists, why we exist. It is not necessary to invoke God to... set the universe going." [2, p. 180]

I have two comments. First, the *Brief History of Time* conclusion trumps this *Grand Design* conclusion. For this only postpones the question of why to the level of asking why the law of gravity is the way it is, not to mention asking why there is physical spontaneous creation. Second, spontaneous physical creation is neither logically necessary nor even physically necessary. The statement 'The universe exists' is logically contingent on its face. And unlike the case of God, there is no ontological argument that the Universe must exist due to any logico-metaphysical necessity. Thus the Universe can only be physically necessary at best. But it cannot even be that. For the uncertainty principle of Quantum physics applies to everything that is physical. As we saw, Hawking says physical laws operate only "within the limits set by the uncertainty principle" [3, p. 126]. The most that can be said is that the spontaneous creation of the universe is very highly probable - perhaps as probable as that the Sun will rise tomorrow, but still only probable. Of course, if we say that over a period of time, the primordial quantum soup was bound to create a Big Bang sooner or later, then we have just admitted there *was* a period of time before the Big Bang - a period of time during which a whole plenum of bubbling events was going on.

Does the uncertainty principle apply to itself? That is, is the uncertainty principle itself uncertain because it applies to itself? It is supposed to be as certain as anything can be in Physics. But how certain is that? Hawking says "Quantum physics agrees with observation. It has never failed a test, and it has been tested more than any other theory in Science." [2, p. 74] But on the deeper level of the nature of scientific theory, Hawking follows Karl Popper's 'falsifiability' Philosophy of science, on which a scientific theory can never be conclusively confirmed by observation, but can be falsified by a single observation [3, p. 10]. Thus though the uncertainty principle has never been falsified and might never be falsified, it is still in principle always falsifiable by a recalcitrant observation in the future. And that is not the same as the uncertainty principle's making itself uncertain. But this does not answer the question. The uncertainty principle does not apply to itself because it is not self-referential. Nor does it apply to everything there is, including itself. It simply states that we cannot be sure of both the position and the speed of a particle, and the more certain we are of one, the less certain we can be of the other. The uncertainty principle is not about itself. It is about particles, positions, and speeds, and the principle is not a particle, a position, or a speed.

In seemingly implicit reply to my two comments, Hawking and Mlodinow say, "Why are the fundamental laws as we have described them?.... We've seen that there *must* be a law like gravity,... and we saw... that... the theory [of gravity] *must* have what is called supersymmetry [at least if the Universe is to include human beings the way it does now] ...." ([2, p. 180-181], my emphasis)

I have two comments here too. First, once again this only postpones the 'why' question. Why must the fundamental laws of Physics be the way they are? Second, Hawking and Mlodinow are evidently appealing to the anthropic principles to answer that question. And unfortunately, the anthropic principles will not help at all. All the anthropic principles say is that *if* (or given that) we exist the way we are now, *then* the Universe must have started in such and such a way [1, p. 56-57, 70, 84; 2, p. 153-155, 164-165; 3, p. 128-131, 137, 142, 155, 180, 182, 200, 209]. They do not even try to tell us *why* we exist the way we are now, nor, therefore, *why* the Universe must have started in such and such a way.

Such reasoning backwards from effect (us) to cause (origin of the Universe) can only tell us the how, not the why. Thus any arguments based on the anthropic principles are deeply unlike Kant's transcendental arguments asking, How is it possible for things to be thus and such? For Kant's arguments, if sound, *do* explain the why. For they aim to ground *metaphysically* why things are thus and such. And just as Hawking says, that is a basic difference between Philosophy (the why) and Science (the how). Granted, even Kant's arguments are liable to the criticism that they are based on the world as we happen to find it. But that is not a problem for Kant. If the possibility of my having free will is grounded in my transcendental being as a noumenal self, the why is explained, even if it is only a logically contingent fact that I happen to have free will. That actually is Kant's view on free will, but I offer it only as a hypothetical illustration of what transcendental arguments try to do.

Indeed, why are the anthropic principles the way they are? For their degree of applicability would differ in different universes with different kinds and degrees of physical laws, all the way to being totally inapplicable in totally random universes which happen to have human beings. And on the Feynman sum over histories method, there will be indefinitely many universes with few or no physical laws.

And what about the sum over histories method? Why does that work? Like the anthropic principles, and indeed the whole of physics, it is logically contingent, and depends on some modicum of physical law. Are there not indefinitely many universes in which the method will not work? Nor can the anthropic principles or the sum over histories method help explain why each other work, but at most how, since the same 'why' question applies to both, and to the whole of Physics, as Hawking is well aware.

Whether Hawking intended his Big Bang argument, in the text I quoted at the beginning of my paper, as merely a brief overview, in contrast to his more considered views elsewhere, I must leave his readers to judge. But a more considered view on our part would be that he is rethinking the material every time he writes, a little differently each time, and this is not one of his better times, perhaps because it is simply too brief and quick at that point in that book. In any case, I have just argued that his view at the end of *Brief History of Time* is his best and most considered view.

## 5. The limited scope of ex nihilo nihil fit

I close with a brief discussion of the principle *ex nihilo nihil fit* (out of nothing, nothing comes). It is a synthetic (if not analytic) *a priori* truth on its face. Hence it belongs to Metaphysics, not to Natural science. It can play a role in Natural science only in the way that logic and Mathematics play a role in Natural science. And Natural science cannot disprove it, for the very reason that it is logically necessary in the wide sense of *a priori* truth. But the statement 'At first there was nothing, and then there was something' is logically contingent on its face. And if God creates something where before there was nothing, the something is not coming out of nothing, but out of a world with nothing *but God*, that is, a world with God and nothing *else*. And since *ex nihilo nihil fit* is logically necessary, the something that God creates in a world with nothing but God can only come out of God, since there is nothing else there for it to come out of. It is not as if God is fashioning the world out of nothing, as if nothing were some kind of raw material. And the statement that 'In a world where there is nothing but God, something that God creates is something that comes out of God', is a synthetic (if not analytic) *a priori* truth on its face. And two truths, *a priori* or not, cannot contradict each other. Thus the principle *ex nihilo nihil fit*, though necessarily true, is irrelevant. Thus when we say 'God created the world out of nothing' that cannot contradict that principle, and can only mean that before God created the world, there was nothing *but God*. Thus God's creation of the world would be beyond the scope of application of *ex nihilo nihil fit*. Likewise for the creation of the world by the quantum soup. The world would not be coming out of nothing, but out of a world with nothing *but quantum soup*. It is not as if the quantum soup was fashioning the world out of nothing, as if nothing were some kind of raw material. And while the total *energy* of the soup was nothing, the soup itself, that is, the *particles and antiparticles* whose energy cancelled out to zero, was not nothing. In fact, the total energy of the world as it is now, full of stars and planets, cancels out to nothing too! For "the total energy of the Universe is zero" [3, p. 133]. Yet the stars and planets are not nothing.

## 6. Suggestions from an anonymous reviewer

I thank a very kind anonymous reviewer for two suggestions, which I will state in my own way.

First, 'quantum soup' may be more precisely called 'continuum of potential mass-energy'. That is a real potential in Aristotle's sense, as opposed to a mere logical possibility. For any real mass-energy that emerges has at least a slight physical probability. Thus the potential exists in the sense of belonging to the physically real order. In contrast, there is no such thing as a merely possible unicorn. A merely possible unicorn is at most an object of thought, and in the case of dreams or hallucinations, an object of perception. But the quantum soup is no mere object of perception or thought. It is out there, even if we cannot describe it independently of our observations. In fact, it is a purely physical matter that photons strike an object when we shine a light on it, and that we cannot measure place independently of motion. Thus our observations in Physics are part of the real order too, in a way that dreamed or hallucinated observations are not. And even dreams and hallucinations are presumably part of the neural order in some sense.

Second, 'before' and 'after' at the quantum level might be better called 'causally prior' and 'causally posterior', or even 'physically antecedent' and 'physically consequent', so as not to confuse these relations with before and after in the ordinary macro-object sense. And that would include the quantum soup's existing 'before' the Big Bang. This suggestion can be based on an analogy to talk of logical priority and of ontological priority, neither of which is temporal. Now, we have repeatedly seen that Hawking himself does not hesitate to use ordinary temporal terms for the quantum level, and seems to mean that quanta go back in time and affect the past quite literally. But we can certainly play safe in our terminology if we wish. And just as the reviewer says, it will not affect the argument in the slightest. Even if nothing caused the Big Bang, the quantum soup was still physically antecedent. For without it, the Big Bang could not have probabilistically happened to pop out of it and into (actual as opposed to potential) existence. Note that quantum probabilities are epistemic probabilities only because they are more deeply physical probabilities. And the distinction between potential and actual existence is basically just the distinction between unstable flux and an emergent, more stable and predicable world. It is a bit like Aristotle's distinction between matter and form, and even a bit like Plato's world of flux and forms.

In conclusion of this paper, if I am right, then far from objecting to my critique, Hawking himself would seem to agree with it.

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