# Is Big Bang Cosmology in Conflict with Divine Creation?

• Fr. William R. Stoeger S.J. •

**What is the Big Bang?**

There is compelling evidence that our universe emerged from an extremely hot, dense primordial state about 14 billion years ago – the Planck era, which is often considered the direct result of the Big Bang. From that fiery epoch it has gradually expanded and cooled. And as it cooled it has become more and more lumpy, and more and more complex. As ever lower temperatures were reached, simpler more basic entities and systems combined and formed an ever more complex and diverse array of evolving systems – particularly in cooler, more protected, more chemically rich environments.

But what is the Big Bang? Strictly speaking, it is the past limit of the hotter, denser phases we encounter as we go back farther into the history of the universe. Not only is it observationally inaccessible, but it also lies outside the reliability of the classical (non-quantum) cosmological models upon which we depend.

This does not mean that there is

***Right*** *Fr. Georges Lemaître with his mentor Sir Arthur Eddington in 1938.*
Credit: *"Archives Lemaître"*
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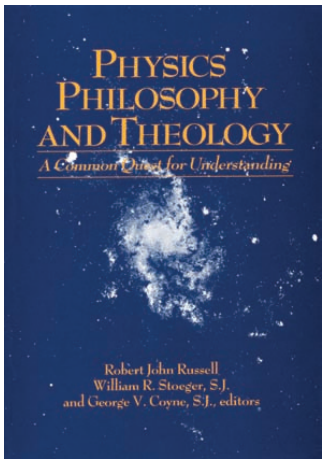
no evidence supporting Big Bang models. There is pervasive compelling evidence from a number of independent quarters – most notably the cosmic microwave background radiation, the universality of large systematic redshifts of distant galaxies, and the abundances of deuterium, helium and lithium. There is no doubt that, as we go back farther and farther into the past, the universe was hotter and hotter and denser and denser. The observational inaccessibility is of the earliest hotter denser phases, and of whatever event or state triggered the universe's expansion and cooling.

What will quantum cosmology be able to tell us about it? By considering the recent educated scientific speculation on what may have led to the Big Bang and the Planck era, we shall find that quantum cosmology – and the physics upon which it relies – promises to reveal a great deal, but cannot provide an alternative to the traditional philosophical notion of divine creation, creation from nothing, in accounting for the universe's ultimate origin. Any understanding it might provide, no matter how physically fundamental, will require a deeper explanation or basis for its existence, order and properties. In other words, it will not be self-subsistent or self-explanatory. But at the same time, quantum cosmology indirectly poses these ultimate questions, which it cannot answer, and in so doing, points towards – and is consonant with – divine creation.

### The Planck Era and "the Beginning" of the Universe

But what about the Planck era and the Big Bang? What generated this extreme primordial state? Was this the very beginning of the universe?

If we go all the way back in time




as far as we can go, we find that at a certain point our standard model of the universe describes it as having infinite temperature and infinite density. In the version which best fits what our universe is like, this point, which is often referred to as "the initial singularity" or "the Big Bang," would have occurred about 13.7 billion years ago – but only the tiniest fraction of a second before the universe was at the temperature of the Planck era, $10^{32}$ K.

There is a problem, however, in taking this "initial singularity" or "Big Bang" point seriously. The fact that it involves infinite temperature and infinite density serves as a warning that this did not actually happen. It is simply a "prediction" of the model which does not represent what really occurred. In fact, there are very strong indications that the key assumptions upon which this very reliable model is based – those of Einstein's theory of gravitation, general relativity – break down when the universe is at or above the Planck-era temperature. The model is very reliable below that temperature, but severely fails in describing the physics and behavior during the Planck era itself, or during any era preceding it.

*Quantum cosmology indirectly poses ultimate questions which it cannot answer...*

***Top*** *The Vatican Observatory and the Center for Theology and the Natural Sciences at Berkeley have published a series of books on the relationships between modern science and theology, to which the author of this chapter has served as a contributor and editor.*

From this discussion we can clearly see, then, that the Big Bang, or even the Planck era, is not "the very beginning" of the universe. It certainly is "the beginning" according our provisional models of the universe. But those models are completely inadequate precisely in the region of the Big Bang! Thus, on the basis of what we know so far we can say very little about the Big Bang and Planck era, or about what generated them. As we shall see, however, research in quantum cosmology – though not yet yielding complete and reliable results – has begun to shed some significant light upon some possibilities and some of the characteristics of that primordial cosmic state.

Eventually, from a philosophical point of view, we shall want to determine whether or not an adequate theory of the conditions in the Planck era, and a reliable account of what led up to it, will ever be able to model an "absolute beginning" of the universe. Or more fundamentally, are physics and cosmology capable of providing an ultimate explanation for the universe and its principal features? If so, then they would be viable alternatives to the philosophical *creatio ex nihilo* idea of creation, which constitutes the basis for the theological doctrine of creation in Judaism, Christianity and Islam. If not, then they would be complementary, and not on a level equivalent to that of

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philosophical or theological explanation. But before we delve more deeply in that issue, we look briefly at what quantum cosmology is suggesting.

**Insights from Quantum Cosmology**

Why does the basic physics underlying the standard cosmological models, and their modifications (e. g. the addition of an inflationary epoch), break down at the very high temperatures, or energies, which characterize the Planck era? One simple answer is to say that the universe is too hot for space and time (or more correctly space-time) to exist as smooth continua. The fluctuations in geometry are so large that the concept of space-time as we usually model it – as a smooth, connected manifold – is no longer valid. Instead we have to find an adequate way of representing this highly energetic state with a discrete, broken-up, foam-like structure, which becomes space-time when the temperature falls below $10^{32}$ K, and the universe emerges from the Planck epoch. In other words, we need a quantum description of space-time and therefore of gravity. This is because the basic physics of space and time is intimately linked with the gravitational field, which in turn is determined by the mass-energy distribution throughout the universe. (Remember mass and energy are equivalent: $E = mc^2$!) Mass-energy generates gravity and therefore space-time, but space-time and gravity in turn tells mass-energy how to move. We thus need to somehow marry Einstein's gravitational theory, which wonderfully and accurately describes this fundamental link, with quantum theory, which deals with the particle-and-wave-like character of reality at submicroscopic levels. So far this challenge has proved extremely difficult, and has not been met.

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Over the past 40 years or so there have been a number of different approaches which have been taken towards developing a fully reliable theory of quantum gravity which could be used by quantum cosmology to describe the very early universe, and therefore the Planck era and what may have possibly preceded it or led to it. At present the most highly developed and promising of these are superstrings, loop quantum gravity and noncommutative geometry. I shall not spend time here describing these fascinating and tantalizing ideas in any detail. There is just not space here for that. (For a readable introduction to these ideas in this context, see Lee Smolin's book, *Three Roads to Quantum Gravity*, published by Basic Books in 2001.) Here I shall just mention some of the other consequences, or preliminary conclusions, such theories suggest for quantum cosmology.

But first we must realize there have been a number of significant contributions to quantum cosmology apart from those directly connected with developing a full and adequate theory of quantum gravity, or a fully unified theory of all four fundamental interactions. These have been what might be called semi-classical quantum cosmology treatments. These incorporate some of the basic insights from standard quantum theory and from Einstein's general relativity and may indicate some of the key features which characterize the Planck era and what led to it. (As Chris Isham has emphasized, "certain general properties are expected to hold in any quantum gravity theory…") These approaches are enabled by the requirement that any quantum cosmology or quantum theory of gravity must, as the temperature or energy decreases, yield the reliable classical, or non-quantum, models we already have

– like the standard cosmological model. Working the other way, we can construct the semi-classical quantum versions of these classical models and see what sort of quantum corrections are expected to occur as we go to slightly higher temperatures which trigger the transitions to the quantum-cosmological regime.

Among some of the key people who contributed to such approaches are John Archibald Wheeler, Bryce DeWitt, Stephen Hawking and James Hartle, and Alex Vilenkin. Wheeler and DeWitt formulated the very elegant and suggestive Wheeler-DeWitt equation which describes in simple terms the behavior of the quantum-mechanical "wave-function of the universe." This cosmic wave function would under certain conditions have a definite probability of issuing in our classical universe, which would then expand and cool, as general relativity and the standard universe models prescribe. It is important to realize that the Wheeler DeWitt equation does not contain time as such. In the purely quantum regime the wave function of the universe in some sense "just is." However, there is a sense in which time can emerge from the Wheeler-DeWitt equation as the transition between the wave-function of the universe and the classical universe itself occurs. Hartle and Hawking later extended this work, and showed, by using the concept of imaginary time – by which one treats time exactly like a spatial dimension – and by conceiving that there is no initial 3-dimensional spatial boundary to the universe, that we can in a consistent way obtain from the cosmic wave-function a universe like the one we inhabit. They also obtain a very early inflationary phase for this universe, which seems to be required. This is called "the Hartle-Hawking no-boundary proposal" for the origin of the universe, an amazing idea and result, but one which depends on a number of assumptions which are not easy to justify.

*Physics can never tell us how we get from absolutely nothing to something.*

(For a non-technical description, see C. J. Isham's article, "Creation of the Universe as a Quantum Process," in *Physics, Philosophy and Theology: A Common Quest for Understanding*, edited by Robert John Russell, William R. Stoeger, S. J., and George V. Coyne, S. J., and published by the Vatican Observatory in 1988.)

It is notable that the Hartle-Hawking proposal has been touted by some as indicating that physics and cosmology now can provide a universe emerging from "nothing." Because there is no boundary, nor any classical time, that can be defined, there is a sense in which the physics seems to indicate that it "just appears from nothing." However, this is an illusion, at least from a philosophical point of view. At the very least one needs the existence of the wave-function of the universe and the ordered behavior described by the Wheeler-DeWitt equation itself. Where did these come from, or why are they as they are, rather than as something else?

Furthermore, as M. Bojowald and H. A. Morales-Técotl have pointed out, this proposal really does not eliminate the singularity, which they accept as "a point of creation." This is clear because the wave-function does not vanish at the singularity. The Wheeler-DeWitt equation, and proposals for solving it, like that of Hartle and Hawking, and Vilenkin, present simplified models, or descriptions, of some features we might expect from the quantization of the gravitational field, and of the early universe. But they are by no means adequate. They should approximate what happens far from the singularity, but they certainly are incapable of describing what happens near it. Much less do they describe "the process" by which the creation of the universe took place, understood in the radical philosophical sense.

String theory has recently generated two other popular but still inadequate scenarios for triggering the Big Bang and providing a possible way of understanding the emergence of the universe from the Planck era. One is "the pre-big-bang scenario" and the other is "the ekpyrotic scenario." Because of symmetries in string theory, including time-reversal and what is called "T-duality," two completely different phases of the universe are allowed – a pre-big-bang phase, in which the universe collapses from from an almost empty state an infinite time ago, to become very dense and very hot leading to the Planck era. However, like many other quantum gravity theo-

ries, string theory does not allow a singularity – the volume has a minimum, and the density, temperature and curvature have maxima. When these are reached, the universe bounces and enters the post-big-bang phase. Thus, according to this suggestion, it is very clear that the Planck era and the Big Bang are not the beginning of the universe, nor even of time. One of the principal difficulties with this suggestion is that there is not yet a satisfactory account of how the transition (the bounce!) from one phase to the other may have occurred. In the ekpyrotic scenario, our universe is simply one of many large membranes (D-branes) floating in a higher dimension space. These "branes" are a natural consequence of string theory. Periodically, because of the gravitational attraction between them, these branes collide with one another triggering a big-bang-like event. However, not any pair of colliding branes will yield the Big Bang and the universe we have. For two branes to do that would require that the branes themselves and the collision between them be "finely tuned" or carefully orchestrated. For instance, the branes involved should be almost exactly parallel. (I am indebted to George Ellis, the well-known cosmologist from the University of Cape Town, for pointing out this qualification to me.)

A general and fundamental conclusion we can draw from our brief discussion of quantum cosmology is: Any more reliable scenario for the origin of the Planck era, and the triggering of the expansion and cooling of the universe from that state, requires other detailed physics describing some physical structure or states which in some sense underlie or explain the Planck era itself. Any such account will always demand some further explanation or physical foundation – and ultimately an adequate metaphysical foundation or ground. As George Ellis has remarked, quantum cosmology assumes that all the structure of quantum field theory, superstrings, or other organizing structures, pre-exists the universe itself, since they determine its emergence. So, where does all of this structure reside? And how does it trigger the coming into being of the whole physical universe? We might also ask with Ellis, where do these structures reside after the universe has emerged? These questions push us beyond where the natural sciences, or perhaps any human inquiry, are able to take us.

Physics as such can specify in great qualitative and quantitative detail how we get from one physical state to another, or what the underlying constituents or factors of a given state are. It can do this if it has adequately modeled the regularities and relationships involved. However, it cannot in principle account ultimately for their existence or for the particular form those structures, regularities and relationships take. To put this in temporal terms, which are not essential to the issue, physics can never tell us how we get from absolutely nothing – no space or time, no matter or energy, no wavefunction or field, nothing physical at all – to something that has a particular order. There is no physics of "absolutely nothing." Thus, though physics can shed a great deal of light on many other questions having to do with the universe, it evidently cannot help us in illuminating the ultimate ground of order or of being. This is precisely why physics in general, and quantum cosmology in particular, do not provide an alternative account of the creation of the universe, philosophically or theologically speaking.

*The Creator empowers the physical processes to be what they are. The Creator does not replace them.*

And so now we turn to discuss the philosophical concept of "creation from nothing" – *creatio ex nihilo* – as a complementary, not an alternative, understanding of the origin of the universe, and of reality in general.

### The Basic Insight of *Creatio ex Nihilo*

The basic reason why *creatio ex nihilo* is complementary to any scientific explanation, including whatever quantum cosmology theoretically and observationally reveals about the "earliest" stages of our universe – or multiverse – and not an alternative, is that it does not and cannot substitute for whatever the sciences discover about origins. It simply provides an explanation or ground for the existence and basic order of whatever the sciences reveal. The Creator empowers or enables the physical processes – including whatever primordial originating processes and entities, whatever they are – to be what they are. The Creator does not replace them. Nor, as we have just seen above, can what quantum cosmology discovers and models substitute for what *creatio ex nihilo* accomplishes – that is, providing an ultimate ground of existence and order. In our discussion at the end of the previous section we found rather strong indications that any physical process or dynamical structure that would account for, or generate, the extreme conditions marking the Planck era, or triggering "the Big Bang," requires a more fundamental physical explanation or grounding. Nothing we are familiar with in the physical or biological worlds – or in reality generally – stands on its own without requiring some cause and context. Nothing we can investigate scientifically completely explains its own existence and characteristics. Thus, whatever we find in quantum cosmology will always raise further questions for understanding.

> Creatio ex nihilo *is not an answer to the question of temporal origin...* Creatio ex nihilo *is, instead, about the ultimate ontological origin of reality...*

Thus, an infinite regress of questions of physical origin is inevitable. And no member of this chain of origins, nor the entire chain itself – even if its infinity were realized – would provide an ultimate grounding for existence and order.

What *creatio ex nihilo* provides, then, is an ultimate ground of existence and order for the universe – and for reality as a whole. It does this by proposing a self-subsisting, self-explanatory "cause" – the Creator – which is the fundamental source of being and order, and in which all existing things participate. As such, this ultimate ground of being and order is not another entity or process in the universe, which can be discerned or isolated from other physical causal factors and entities. It is not scientifically accessible! And yet it is causally distinct from them, because, without it, nothing would exist. As such it does not substitute for created causes – it endows them with existence and efficacy. One way of putting it is that this Creator, however we attempt to describe it, is the necessary condition for everything, and the sufficient condition for nothing. Events and changes occur, and entities and systems emerge and subside into their components, only through the created, or "secondary causes" which the Creating Primary Cause sustains. In fact, the rich philosophical tradition shared by Judaism, Christianity and Islam uses the complementary categories primary cause and secondary cause in just his way.

(Many people have written about *creatio ex nihilo*. For brief summary treatments, you might want to look into Catherine Mowry LaCugna's *God for Us: The Trinity and Christian Life* (published by Harper-SanFrancisco in 1993); Langdon Gilkey, "Creation, Being, and Nonbeing," in *God and Creation: An Ecumenical Symposium,* edited by David B. Burrell and Bernard McGinn, and published by the University of Notre Dame Press in 1990; or my own articles, "The Origin of the Universe in Science and Religion," in the book *Cosmos, Bios, Theos: Scientists Reflect on Science, God, and the Origins of the Universe, Life and Homo Sapiens*, edited by Henry Margenau and Roy A. Varghese, and published by Open Court in 1992; and "Conceiving Divine Action in a Dynamic Universe," in *Scientific Perspectives on Divine Action: Twenty Years of Challenge and Progress*, edited Robert John Russell, Nancey Murphy, and myself and published just this past year by the Vatican Observatory Publications and Center for Theology and the Natural Sciences.)

Presuming for the moment that there are no serious reasons for dismissing the basic concept of *creatio ex nihilo*, how can we understand it better?

First, it is crucial to realize that when we talk about God, or "the Creator," we will never be able to have an adequate concept of that. It will always be beyond us – radically transcendent. But at the same time, we can point to the mystery of existence and order at the depths of reality and of our experience, and say something very tentative

about creation and what it requires. There will be some ways of speaking about God and God's creative action which are less inadequate than others! In the same vein, we have to acknowledge that, when we talk about God "causing" or "acting" when God creates, we are speaking metaphorically or analogically. God acts or causes in a very different way than anything in our experience acts or causes. And yet there is some legitimate content to those assertions, in the sense that God somehow endows things with existence and with their specific being in the ultimate sense, but also through the action of other created causes, which God also holds in existence. Without God, they would not exist! Thus, God as Primary Cause is a cause unlike any other cause – unlike the created, or secondary causes, which God sustains and enables. God is their necessary condition.

Secondly, *creatio ex nihilo* is not primarily an answer to the question of temporal origin. It's an open philosophical question whether or not there was something like a temporal beginning to creation – a first moment, as it were. Certainly, as we have already seen, quantum cosmology points to the separation of the first moment of time as we know it from the origin of the universe itself, if there was one. *Creatio ex nihilo* is, instead, about the ultimate ontological origin of reality – most fundamentally it describes in a very bald and unadorned way the ultimate dependence of everything on the Creator. It is not about a creation event, but about a relationship which everything that exists has with the Creator (as noted by LaCugna). So *creatio ex nihilo* is also *creatio continua*, continuing creation. The relationship between the Creator and the created continues as long as something exists. The Creator sustains or conserves reality – and the universe – in existence. Without God, it would not exist. It has been helpful to conceive the relationship of creation as a participation in the being of the Creator. In this regard, it also seems clear that it is better to conceive the Creator more like a verb, than like an entity. In some ways, the Creator is pure, self-subsisting being, activity, or creativity, in which all things participate. Traditionally, some philosophers and theologians have traditionally referred to God as "Pure Act."

Thirdly, it is also critical, as we have already implied, to avoid conceiving the Creator as controlling creation, or as intervening in its dynamisms. God, instead, enables and empowers creation to be what it is – and both ultimately endows and supports all the processes, regularities and processes of nature with their autonomous properties and capacities for activity. Thus, God as Creator does not substitute for, interfere with, countermand, nor micromanage the laws of nature. They possess their own integrity and adequacy, which God establishes and respects.

*Quantum cosmology and* creatio ex nihilo *contribute deeply complementary and consonant levels of understanding of the reality in which we are immersed...*

Fourthly, it is often claimed that God as creator, though transcendent, is immanent in creation and in its activity. Though God as Creator does not function within nature or history as another created (secondary) cause, God is present and active in and through the whole network of processes and relationships, precisely because God is sustaining them and enabling them. We can better understand this by pointing out that transcendence is not about being above and beyond creation as detached from it, but rather being free from any barriers, limitations or obstructions. Thus, there is no barrier to the ground of being and order being immanent – deeply present and active, but present and active as Creator, not as another created cause – within all aspects of creation. Transcendence does not impede or contradict immanence – it enables it!

Fifthly, the relationship of ultimate dependence and creative immanence is

not uniform, but instead is highly differentiated – that is, it is different with respect to each entity, organism, system, person and process. God sustains them all in being, but God is sustaining different things in being, with different properties, capacities and individualities – and through different constitutive relationships with the world around them. And each responds to its environment and to the situation within which it finds itself – and therefore to God – in different ways.

There is much more that could be discussed about *creatio ex nihilo* and how it is to be coherently understood. But what I have presented here captures the essence of the approach in a way which helps us appreciate the fundamental question it attempts to answer, and why, if properly understood, it cannot be in competition with cosmology or the other natural sciences in explaining the origins of the universe, or of anything emerging within it.

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## Conclusion

Now that we have looked carefully at the way physics, cosmology and quantum cosmology probe the origins of the universe and the objects and systems that emerge within it, and explored the essential contents and limitations of *creatio ex nihilo*, we can see more clearly how different they are from one another. In particular, we begin to appreciate the detailed scenarios which quantum cosmology constructs and tests, as well as the need to find a physical explanation for any stage of cosmic development, no matter how primordial. By their very nature, physics and cosmology, as do the other sciences, will always focus on how we get to a particular outcome from another physical configuration by some transition, process or change. Thus, they attempt to describe in qualitative and quantitative detail "the first" configuration and the physics that enables the transition to the outcome in question. This has proved extremely powerful. However, it has the limitation that it is can never deal with the essential ground of being and order, upon which all else rests. *Creatio ex nihilo* as a philosophical – not a scientific – approach attempts to do that. Properly applied it is not about changes, processes, or transitions – it does not, and cannot, substitute for anything that the sciences legitimately accomplish and validate. It merely – but powerfully – complements our quest for understanding and explanation of origins by supplying a "bare-bones" but compelling resolution to the basic issue of the ultimate ground of existence and order.

Thus, quantum cosmological scenarios or theories – which describe the Planck era, and the Big Bang, or which describe the primordial regularities, processes and transitions connected with these extreme very early stages of the universe – are in principle incapable of being alternatives to divine creation conceived as *creatio ex nihilo*. They simply do not account for what *creatio ex nihilo* provides – the ultimate ground of existence and order. Reciprocally, *creatio ex nihilo* is not an alternative to the processes and transitions quantum cosmology proposes and provides – these are models of the physical processes which generated our universe and everything emerging from it. *Creatio ex nihilo* by itself cannot, and was never intended to, usurp the role these, and the laws of nature upon which they depend, play in the universe. Instead they are precisely the material, physical expressions and channels of its continuing operation. Thus, quantum cosmology and *creatio ex nihilo* contribute deeply complementary and consonant levels of understanding of the reality in which we are immersed. Exactly the same point can be applied to divine creation and biological evolution – they are not exclusive alternatives, but rather complementary accounts, linking the ultimate ground of being and order with their elaboration in concrete structures, dynamisms, processes and transitions.



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*This article is a highly abbreviated version of the chapter, "The Big Bang, Quantum Cosmology and Creatio ex Nihilo," to appear in* Creation and the God of Abraham, *edited by Janet Soskice, David B. Burrell, Carlo Cogliati, and William R. Stoeger, forthcoming from Cambridge University Press.*