FINITE CREATION WITHOUT A BEGINNING:
The Spiritual and Theological Significance of Stephen Hawking's Quantum Cosmology

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I OFTEN RECALL THE VACATION my wife and I took some years back to the exquisite islands of the far South Pacific. For endless hours I would float on my back in the warm, salty waters of Bora Bora, seemingly suspended midway between the fathomless depths of the azure Pacific below and the reachless vault of the beckoning, blue sky above. I could feel the rubber mat scraping my sunburned back, the gentle lifting and tilting rhythm of the ocean's pulsations, the lap of warm water and foam on my skin, the pulse in my throat. Amidst these sensations I felt a deep wonder and a feeling of eternal belonging to the waters below and the sky above.

For I am a creature of this vaulted watery world and I am of a piece with the waters below and the sky above. From water I came; out of water I am made. My organs and cells, my intricate metabolic pathways and the detailed instructions carried in the four-letter alphabet of my genes, indeed all that makes up my body evolved through countless generations of creatures: creatures of salty oceans, searing deserts, dripping rain forests and grassy plains, creatures who seek out others for food, for procreation and, over the aeons of evolution, creatures who have searched, with a dim but growing sense, for community—creatures who, at least with the arrival of *Homo sapiens*, possess and are possessed by a restless longing for the ground of being in which, through which and by which all life and history transpires.

I am also a child of stardust, whose story can be traced back to a time before the earth was formed, back to a generation of stars now gone forever, but whose violent deaths in supernovas transformed stellar hydrogen into the dust that eventually became our planet—and my flesh. Hence, alive now in this place, I am connected to earth and sky by biology and cosmology. I breathe in the universe and give it out again. Like breathing, the movement of the ocean of water on which I float and

the ocean of salt water flowing through my arteries and veins interconnect and lead me beyond myself, beyond my immediate world, to a sense of connection with the vastness above and below. I am humbled by that vastness and by my dependence on all that is.

Yet beyond these feelings was something else both unsettling and compelling. As I floated on that mat I faced the realization that even this universe has a fragile existence like my own. The universe itself is ultimately an enigma. In realizing this, I began to feel at last the revealing presence of that which infinitely surpasses both me and the universe, while yet being indescribably close to me: the source and ground of all existence, the supreme reality, the necessary existence out of whom all existence comes into being. In that moment, floating on the raft, I too experienced what the mystics understand as numinous encounter with a divine mystery, an experience laced with awe and fear, an encounter which Rudolf Otto called the *mysterium tremendum et fascinans.*[1] The sense that we utterly depend on the world—the universe!—for our existence thus leads to a deeper insight: that the existence of the universe itself is ultimately mysterious and, like us, dependent. And so our existence in this universe opens us spiritually to the experience of God as the ground, source and goal of the universe as a whole.

What is so marvellous about recent science, I find, is that this insight can be enhanced enormously by the striking nature of the scientific theories themselves and by the humble approach science requires of its practitioners.[2] Now of course, scientific theories are constructed for non-religious reasons, and they function extraordinarily well for the kind of questions they are addressing at both the cosmological and the atomic levels without any explicit reference to God. Yet the way these theories account for nature raises further questions rooted in the theories but pointing for their answers beyond science into philosophy and theology. For example, what do we mean by space, time, matter and causality? Did time have a beginning? Is the universe infinite and eternal or does it have a boundary? Will all things end one day? Why is the universe compatible with life in the first place i.e. why is it compatible with the very precise global conditions necessary for the evolution of life?[3] Perhaps most basic of all, can science alone account for why the universe exists?

For many people such questions abound with increasing intensity as they read about science and the on-going discoveries in cosmology and particle physics. Books like Stephen Hawking's *A brief history of time*[4] produce in us a sense of awe at the overwhelming grandeur and

immensity of nature and the staggering concept that it may have had an absolute beginning—and this leads many to feel closer to God as the ultimate, creative source of the universe and of us who live out our lives within it. Yet, in a strange turn of affairs, Hawking himself seems to believe that physics will both cut off the need for God to create the universe while still giving us a way to read God's mind. What are the bases for his conclusions? What makes Hawking's writing, and that of other science writers today, so spiritually evocative?

To respond to these questions we must first understand a bit more about cosmology.

Our place in the universe

Floating again on that velvety azure sea at sunset, my eyes play across the palm trees swaying against the sandy shore one hundred yards away. Elegant creatures of green and brown, they thrust high up into the fading blue sky. Suddenly above them I see a brilliant red pinpoint of light: the first star of the balmy evening. It is my familiar friend, Antares, the ruby heart in the venomous Scorpio! Bright Antares seems so close I could almost reach out and grab her as she floats mere inches above the palm tree.

Yet with a shock I recognize Antares as it truly is, free of anthropocentric domestication: Antares, the massive red giant star, lying over five hundred light years away—an unthinkable three hundred million billion miles! Antares, whose swollen, distended mass if placed where our sun now lies would engulf everything within the radius of the planet Mars, including the orbit of Earth. How much stranger this universe is than ever we imagined in our ancient legends of gods and astrologic prophecies, mirroring and manipulating the struggles of mortal folk and displayed against the dome above in starry constellations. Now, as I see more and more stars emerge out of the darkness, my mind undergoes a gestalt switch which grabs the nearness of these shining pinpoints of light and throws them unimaginable distances away. Suddenly the bowl of the heavens becomes transparent to the uncharted immensity of the universe around me and I realize I am gazing at infinity.

What a wrenching change in our self-understanding this century has brought, for we have completed the Copernican revolution beyond the dreams even of Copernicus. It has only been in this century that we have realized how truly distant the stars are and, more than that, how truly ordinary and indistinguishable our star, the Sun, actually is. On a clear night we can see thousands of stars and many, like Antares, are so far away that the light we now see was radiated before Washington,

Shakespeare or even Thomas Aquinas was born. We also now know that all the stars we see at night are part of a single, massive galaxy we call 'the Milky Way'. We lie two-thirds from its central hub along one of its spiral arms. Our galaxy contains in the order of one hundred billion stars and extends one hundred thousand light years in diameter. We also know that this immense 'island universe', as it was once called, is merely one galaxy among billions of galaxies distributed throughout a space so vast that it takes light tens of billions of years to traverse it: the 'visible universe'.

The Big Bang and the beginning of time

Most shocking of all, however, we now believe that all this vast array of galaxies, with their over ten thousand billion billion stars and planets (and life?), is part of a single universe which has been expanding from an initial 'explosion' some fifteen billion years ago. This conclusion is based on the theory of general relativity, proposed by Albert Einstein in 1915, and the results of astronomical observations. If correct, it would suggest that time itself had a beginning.

According to Einstein, space and time form a four-dimensional, flexible continuum called 'spacetime'. The way matter is distributed throughout spacetime affects the shape of spacetime, just as a steel ball lying on an elastic surface deforms the shape of the surface. Spacetime, in turn, affects the way matter moves on it. Thus the changes in the curvature of spacetime caused by moving matter will themselves continually change the shape of spacetime and thus change the trajectories along which matter winds its way.

When this theory is applied to the universe, the results are staggering. According to observations made by astronomers as early as the 1920s, clusters of galaxies are distributed more or less uniformly throughout the universe. Moreover, these clusters are moving apart from each other. This means that the universe as a whole must be expanding—changing its shape in time. Now if the universe is expanding, at some time in the past it must have been infinitely compact and dense. Let us call this event 't=0', where t stands for cosmic time; thus cosmic time began something like fifteen billion years ago. Moreover, as the universe expands it cools, meaning that if we think back to the point of infinite density t=0, the temperature of the universe goes to infinity as well.

Putting this all together, cosmologists believe that, according to the Big Bang model, the universe 'began' at a point of infinite temperature, infinite density and zero volume approximately fifteen billion years ago. Does this mean that t=0 represents the event of the 'creation' of the

universe—perhaps by God? Or should we insist on changing our theories to circumvent the embarrassment of physics leading to a prediction of this kind, a physical event with no apparent physical cause?[5] However we interpret t=0, it is little wonder cosmologist John Archibald Wheeler calls the expansion of the universe the single most important discovery in the books of science.[6]

Theological responses to the Big Bang: did God create time?

Interestingly, the problem of a beginning to the world has been a long-standing topic to theologians. One need only recall the famous solution offered by Augustine[7] that God does not create *in* time, rather God *creates time* along with the rest of the world.[8] The possibility that current science might lead to a theological conclusion such as this has been a tempting target for many.[9] In the early 1950s Pope Pius XII saw in the Big Bang direct support for the Christian doctrine of creation out of nothing; more recently astronomer Robert Jastrow[10] and a variety of conservative theologians have taken a similar tack. Yet others have been much more cautious of the subtle problems involved in such a position. Philosopher Ernan McMullin warns that the Big Bang cannot support theological conclusions about divine creation, but grants that they can be in a sort of 'consonance'. Other theologians, including Ian Barbour, Langdon Gilkey, Arthur Peacocke, and Willem Drees, find little substantive relevance of t=0 to the doctrine of creation, seeing the latter mainly as an ontological/philosophical interpretation of human existence and not a historical/causal explanation of cosmological origins.

A few theologians have tried to navigate between the two extremes of either finding direct relations between t=0 and theology or keeping them in essentially watertight compartments.[11] My suggestion is that the philosophical category of contingency plays a bridge-building role linking the doctrine of creation *ex nihilo* and the t=0 problem in Big Bang cosmology.[12] By contingency I mean, in the most general sense, that which need not be: need not exist, nor exist in the way it happens to exist.[13] Historically, the Christian tradition has been committed to the creatureliness of this world; it need not exist and thus, as contingent, it is utterly dependent on God as its source. Now in order to relate contingency to cosmology, we need to unpack its meaning more completely. One way in which things are contingent is by being finite, limited, bounded. (Other ways include being random, accidental, and so on.) Now one way in which something is finite is by lasting for a finite time, or what I like to call temporal finitude. (Other kinds of finitude include being finite in size, in number, or in some other measurable

quantity.) Temporal finitude, in turn, can involve having a finite past or having a finite future or both. In the case of an individual, being finite in time would imply having a finite age and a finite life expectancy.

Now we can make contact with cosmology in that the universe, according to the Big Bang model, does indeed have a finite age (roughly fifteen billion years). Hence through the bridge of contingency we can pass from *creatio ex nihilo* through contingency to finitude, from finitude to temporal finitude, from temporal finitude to having a finite past and from there to the empirical claim that the universe does indeed have a finite age. In this way we find that the Big Bang model is *consonant* with the Christian claim that the universe as a whole is the creation of God. On the other hand it must be readily admitted that if the universe will continue to exist forever, as most scientists believe it will,[14] then its eternal future may well be *dissonant* with the claim about its creatureliness.[15]

Returning to our opening discussion on spirituality, it seems clear that our own personal sense of being creaturely is echoed with a cosmic resonance by the thought that the universe as a whole is finite. Gazing out at a universe of well over a billion billion galaxies and knowing that all this was once tiny and new-born, one is filled with a sense of awe and mystery, and through it all one senses the presence of the divine pervading the world—the universe—even as it infuses one's own existence as the only guarantor of existence and ultimate meaning.

The Hawking proposal: a finite universe without a beginning

Recently, Hawking, whose scientific research had done so much to contribute to Big Bang cosmology and black hole astrophysics, has developed a new proposal which changes the picture in a subtle but crucial way. Hawking, like many physicists today, recognized that the 't=0' feature of the Big Bang model was a major—perhaps *the* major—problem in theoretical cosmology. In order to get a fresh start on the problem Hawking worked intensively on what is called 'quantum gravity', the quantum mechanical treatment of the gravitational field.[16] Now when we talk about quantum physics we normally mean the kind of physics which applies to atoms, nuclei and elementary particles. It would take us too far afield here to discuss quantum physics in any detail but one thing is essential if we are to understand Hawking's proposal. If the universe really emerged from a state of infinite temperatures and vanishing size then at its earliest states it must be an entirely quantum phenomenon since anything the size of an atom—even the universe itself—is subject to the laws of quantum, and not classical, mechanics, and thus the need for quantum gravity.

Working in collaboration with Jim Hartle, Hawking recognized that a quantum gravity approach to cosmology would mean reversing the merger of space and time into spacetime which had been achieved by Einstein. In essence, time in the Hawking model becomes a superficial feature of nature, and space alone is the fundamental concept. Moreover as we move back in time from the present, we approach but never reach the beginning point 't=0'. In Hawking's model, the universe has a finite past but no beginning in time, no temporal boundary or edge.[17] It is rather like a frayed sweater whose smooth surface turns into a tangle of unravelling threads. The smooth surface never ends at an edge, it just dissolves away into endless pieces. Granted that the universe has a finite age—roughly fifteen billion years, even if we could move backward in time we would never arrive at 'the beginning' i.e. at t=0.

Does 'no beginning' mean God only acts by choosing the laws of nature?

From this model Hawking makes two conclusions. (1) Since there is no beginning to the universe, there is nothing left for God to do except choose the laws of nature. (2) By understanding the underlying laws of nature as chosen by God we can, in effect, read the mind of God. How does Hawking warrant these conclusions from his cosmological model?[18]

Conclusion (1) depends on a prior, though unstated, conclusion: that God can act only at the beginning of the universe and not during the course of natural process. This in turn rests on the assumption that (i) the universe runs according to scientific laws which exclude God's action except by divine intervention and (ii) that God does not intervene in these laws. The only exception to (i) and (ii) would be a beginning to the universe. Let us inspect both (i) and (ii).

(*i*) Throughout the modern period assumption (i) was supported by the *deterministic* nature of the reigning scientific paradigm: Newtonian mechanics. Deterministic laws, such as those of Newtonian mechanics allow one, in principle, to predict the future exactly if all physical forces are known and if the present position and momentum of all particles is given. Though in practice one could never hope to achieve such precise initial conditions or specification of forces, in principle one thought of the future as determined by the present and not open to uncertainty—in the process, leaving the meaning of human free will very much in limbo, it should be noted. Classical physics led to a deterministic, clock-work interpretation of nature which dominated the seventeenth through to the nineteenth centuries.

(*ii*) Hawking also assumes that God does not intervene in the orderly workings of natural processes.[19] This too is a modern assumption shared with most non-fundamentalist theologians and virtually all scientists.

Thus, given a scientific world view shaped by strict scientific determinism and a theological commitment against believing in divine intervention, Hawking can draw his basic conclusion: God's only choices are (i) to elect the initial conditions at t=0 which govern the universe as a whole, making it the kind of universe in which life could evolve and, of course (ii) to make such a universe actually exist. After that, God is through.[20]

But now comes the real significance of the Hawking proposal for quantum gravity. If the universe had no beginning, there is nothing *whatsoever* left for God to do—except to choose the laws of nature. So long as the universe had a beginning we could suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end: it would simply be. What place, then, for a creator?[21]

Theological responses to (1). How might a theologian respond to Hawking here? My own suggestion comes out of my previous interpretation of t=0 and picks up the Augustinian insight that God creates time. Recall that, for me, the significance of t=0 lies in the fact that it represents the claim that the universe is finite in the past (i.e. that it has an age, it has not existed forever). With the Hawking model this claim is maintained. It is only the shape, given this claim, that has changed. With the Big Bang, having a finite age meant having had a beginning, and of course this raised as many problems for scientists as it did for theologians since Augustine's famous insight about creation of, not in, time. But with Hawking one discovers the fascinating claim that there can be age without beginning, or put more abstractly, that the universe can have a temporally finite past without a boundary. What I believe this teaches us theologically is that we can and should distinguish between two distinct but closely situated claims: (i) that the universe, as a creature of God, must have a finite past (that it has not existed forever) and (ii) that in order to have a finite past the universe must have had a beginning. It is the latter, stronger claim that Hawking has showed us is not necessary to the weaker claim about having a finite past. And it is the finitude of the past, and not a beginning point, which I claim is of real importance theologically.[22] And so, from my perspective, Hawking's work can have the effect of disabusing theologians of an unnecessary adumbration to their essential claim about *creatio ex nihilo*. Because of his insistence on the distinction between a finite past and a beginning of time, Hawking has, in effect, helped us claim that the universe is indeed a creation of God, even if it had no beginning. In doing this Hawking's work, even if it does not last within science *per se*, will have been enormously helpful to the

task of Christian theology for, whilst pursuing quantum cosmology, Hawking has pointed out a subtle distinction in the concept of finitude which is pertinent not only to quantum cosmology but to Christian theology. For this we ought to be very grateful. It is precisely this sort of interaction between theologians and scientists which signals the promise of a new, highly creative interaction between theology and science.

Conclusion (2), as we have seen, indicates that by learning the laws of nature, we are able to know the one thing i.e. the laws of nature themselves, which God *did* freely choose, and thus we can know the mind of God.[23] Significantly, Hawking also admits that the existence *per se* of the universe lies beyond the question of its rationality.

> What is it that breathes fire into the equations and makes a universe for them 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? Or does it need a creator . . .?[24]

Finally Hawking gives us the grand vision: a theory so elegant—and so final—that it will have to be communicable to everyone in some form, and thus eventually everyone will be able to understand at least something of its import. In the future, then, everyone—specialists and non-specialists alike—will be able to enter into the world-wide conversation about God: why God chose these laws and why God then breathed fire into them, producing an actual universe. This truly is a grand vision.

Theological responses to (2). Hawking's is, of course, the ageless vision of the sublime role of human reason in ascending, at least partway, to the knowledge of God. In the Middle Ages it was Dante, taken half-way by Virgil up the slopes to Heaven. Now in one of the best-selling volumes of twentieth-century science writing we see that vision emerge again: by reason alone—though reason now mingled with a modern taste for empirical data—we should be able to know something essential about God. Not, perhaps, the answer to the classical question of whether God exists but one curiously contrapuntal to it, why God created *this* universe. Still it is a sublime vision in which humans discover, through data and the power of thought, the answers to the essential questions of existence.

Yet we must be cautious here, too. Can we really discover the mind of God by reasoning about nature? Virgil, after all, could never escape the realm of Limbo; reason unaided by revelation is incapable of knowing God. Surely we can never jump from our reason inductively to discover the reasoning of God any more than the equations of physics can be used inductively to disclose the structures of human experience. Further-

more, we must ask whether the conception of God we gain through cosmology is really all that related to the God of the Christian revelation. How far, indeed, is Athens from Jerusalem? Moreover, we must bear in mind that science should never be allowed the role of providing theology with its *essential* foundations.[25]

In my opinion, we have yet to respond adequately to the challenge Hawking raises regarding the origin of the laws of nature. These questions are only now beginning to be pursued carefully and the results are not yet in.[26]

Closing thoughts

The questions Hawking poses continue to raise wonderful challenges to Christian theology and spirituality. As we experience the presence of God through faith by grace, and as we reflect on that faith so that our knowledge becomes wisdom by being 'tasted', we must discover ways to allow these magnificent and staggering discoveries of science to infuse our faith with new depth and meaning—we must not fear that they will overwhelm our faith and bring an end to our Christian witness. We must learn once again to make the case that God acts continuously in nature as well as in the interior realm of spirit, for we long to understand our God as acting decisively in Christ for *all* creation, a creation we now know to extend throughout a cosmos of mega-light year proportions.

In my opinion, it is thanks to Hawking's groundbreaking probing of nature's secrets that we can now emerge strengthened in our understanding of the meaning of divine creation. The universe may have had a beginning, and this would be of stupendous importance for science and for Christian theology. But we now know that even if there was no beginning, this universe, like us its living stardust, bears the mark of finitude, the sign of dependence and the glow of being loved by its Creator.

Floating again on that mat between the skies above and the waters below, I return from the realm of quantum cosmology to the reality of living today. It is time to be with loved ones in the intimacy of family and rest. It is also a time to pray for wisdom, to meditate on the divine presence and to dream about my home of skies and waters. For the meaning of Christian spirituality is deepened enormously as I taste the salt of my tears, sense the throb of my heart, feel the rhythm of the waves and, through science, understand something about the wondrous reaches of the starry night, for all of these open me to the presence of God in whom 'I live, and move, and have my being' and from which through Christ I can never, never be separated.

NOTES

[1] Rudolf Otto, *The idea of the holy*, trans J. W. Harvey (Oxford: Oxford University Press, 1923).

[2] Of course scientists are sometimes arrogant about their accomplishments, making claims which go far beyond what their discoveries warrant. Yet in order to pursue science creatively one must undertake an intense discipline involving truth-telling, the willingness to have one's results disproved and submission to the judgment of the community. All this requires a special kind of humility which, when followed consistently, opens one to discover new revelations about the secrets of nature. A recent example of this kind of intepretation of science is given by John M. Templeton and Robert L. Hermann, *The God who would be known: revelations of the divine in contemporary science* (San Francisco: Harper & Row, 1989). See also John M. Templeton, *The humble approach: scientists discover God* (New York: Seabury Press, 1981).

[3] Moreover, scientific theories raise questions about their very status as theories. Are theories 'scientific' insofar as they can be tested by evidence? What constitutes 'evidence'? What is the ontological status of its fundamental concepts? Do successive theories give us an increasingly clear picture of reality, or is reality infinitely more subtle than any scientific model? What is the role of human subjectivity in science? How is verification possible when the object of inquiry is the universe as such? Do the laws of nature describe or prescribe the regularities of natural processes?

[4] Stephen W. Hawking, *A brief history of time: from the Big Bang to black holes* (Toronto: Bantam Books, 1988).

[5] In the 1940s Fred Hoyle and colleagues sought to describe the universe as infinitely old and perpetually expanding. Their 'steady state' model lasted for two decades, until evidence for a universal background radiation at microwave temperatures overturned Hoyle's proposal and strongly favoured the Big Bang model. Since then the Big Bang model has been modified to account for many other puzzling features. The model predicts that the universe will expand as a smooth surface. Yet we know that early on the universe developed 'wrinkles' in the distribution of its matter, primordial inhomogeneities which eventually developed into galaxies and stars. How did the transition from homogeneity to inhomogeneity take place? Recent work by scientists using the Cosmic Background Explorer (COBE) satellite have detected slight inhomogeneities in the microwave background left over from the Big Bang, suggesting that this might be the primordial source of matter clumping. (See for example, 'COBE finds the bumps in the Big Bang' in *Science* vol 256 [1 May 1992] p 612.)

The problems with the Big Bang model have received some explanation in terms of so-called 'inflationary models' in which the very early universe expanded enormously rapidly. Still the problem of t=0 remains, and it continues to raise profound philosophical questions which are only now being explored in depth and nuance. Here the writings of cosmologist and philosopher Bill Stoeger are particularly helpful. See 'Contemporary cosmology and its implications for the science-religion dialogue' by W. R. Stoeger in Robert J. Russell, William R. Stoeger and George V. Coyne, *Physics, philosophy and theology: a common quest for understanding* (Vatican Observatory: Vatican City State, 1988), pp 219–247.

[6] J. A. Wheeler and C. M. Patton, 'Is physics legislated by cosmogony?' in *The encyclopaedia of ignorance* (Oxford: Pergamon Press, 1977), p 21.

[7] St Augustine, *The confessions*, Book XI (Middlesex, England: Penguin Books, 1961); *The city of God*, Book XI (London: Penguin Books, 1984).

[8] In this sense the problem of 'what happened before the beginning' is circumvented. Hawking, incidentally, is aware of this solution, noting it with approval in *A brief history* (*op. cit.* pp 6–7), since it will resonate nicely with his own work in quantum gravity.

[9] For an excellent treatment, see Ernan McMullin, 'How should cosmology relate to theology?' in *The sciences and theology in the twentieth century*, edited by A. R. Peacocke (Notre Dame: University of Notre Dame Press, 1981), pp 17–57. McMullin's article includes a reference to Pope Pius' statement.

[10] Robert Jastrow, *God and the astronomers* (New York: W. W. Norton, 1978), pp 115–116.

[11] See Ted Peters, 'On creating the cosmos' in Russell *et al., op. cit.*, pp 273–296, and 'Preface' in *Cosmos as creation: theology and science in consonance*, edited by Ted Peters (Nashville: Abingdon Press,

1989), pp 11–27; Robert John Russell, 'Cosmology, creation, and contingency' in Peters, *ibid.*, pp 177–209; and 'Theological lessons from cosmology' in *Cross currents: religion and intellectual life* vol 41, no. 3 (Fall 1991), pp 308–321.

[12] See citations in previous endnotes.

[13] Traditionally philosophers have distinguished between four types of modal propositions: (a) the possible (that which can be); (b) the impossible (that which cannot be); (c) the necessary (that which cannot not be); and (d) the contingent (that which can not be). Theologians use the philosophical category of contingency to interpret their claim that all that actually is, is dependent on a necessary being, since all that is can not be, i.e. all that is, is contingent. (I am grateful to Professor John Wright S.J. for emphasizing this distinction to me in an earlier draft of the text.)

[14] Big Bang cosmology includes three distinct versions which are consistent with the data we now have: closed, open and flat. All three versions describe the past history of the universe in essentially the same way—an expansion from an initial singularity—but the predictions for its future differ radically. In the closed version, the universe is finite in size and shaped like a three-dimensional sphere. It will expand to a maximum size and then recollapse to a fiery point like an inverse Big Bang some one hundred billion years in the future. In the open version, the universe is already infinite in size and shaped like a three-dimensional saddle. It will continue to expand and cool forever. Like the open model, the flat model is infinite in size but it has the structure of a three-dimensional plane. It too will expand and cool forever. Which model applies to our universe is a question still being explored by scientists, but most evidence so far suggests that the universe is open—almost flat—and hence it will expand and cool forever.

[15] This latter point needs a great deal of discussion, however, concerning the relation of the divine eternity to the future of creatures, and must be left for another occasion.

[16] As we have already seen, Einstein's theory of general relativity was based on a classical, not quantum, mechanics.

[17] To gain some perspective on this rather staggering claim we need to understand the Hawking model in some detail. We begin by thinking of spacetime not as a smooth four-dimensional continuum, as in the case of general relativity, but rather as a frothy sea of three-dimensional spatial bubbles. From a great distance the froth looks smooth and continuous, and we call this spacetime. But close up the smooth surface turns into a froth of bubbles. Each bubble is one 'moment' in history. If these bubbles can be nested within each other, something like a set of Russian dolls, they produce a smooth, four-dimensional spacetime continuum. But if the bubbles cannot be nested together, no spacetime continuum is possible. Applied to cosmology, when the Hawking bubbles cannot be nested together smoothly, they represent a kind of 'universe' in which there is no flowing time, no history, no past and future, just a universe of variously-shaped three-dimensional geometrics: a set of 'nows' lacking past and future, for they lack any way to be connected together into a single spacetime with its continuous past and future.

How does this apply to our actual universe? According to Hawking our universe has different regions in it. Some of them are nested like Russian dolls, giving the appearance of a smooth spacetime continuum; we live in such a region. Others are composed of separated, disconnected bubbles lacking an overall time parameter to sew them together. As we think back in time from the here and now in our spacetime region, we move from the portion of the universe which looks like a smooth spacetime into the portion where all there is are disconnected bubbles. This means that as we move back towards the beginning of the universe the notion of time 'evaporates' and the problem of 't=0' is solved, but in a curious way. We just can never get there because the time parameter 'unravels' and the continuous, four-dimensional universe dissolves into a sea of three-dimensional bubbles.

Thus, even though the universe has a finite past, as in the Big Bang models, it has no beginning point, no t=0. According to Hawking's interpretation of the universe, t=0 is not a physical singularity as it is in the Big Bang model, but a meaningless abstraction of no physical significance.

[18] For a recent and careful review of the philosophical and theological issues raised by the Hawking proposal, see Willem B. Drees, *Beyond the Big Bang: quantum cosmologies and God* (La Salle: Open Court, 1990).

[19] Hawking, *op. cit.*, p 140.

[20] One might hope to spot an obvious flaw in this conclusion. Surely quantum mechanics has changed our view of determinacy in a radical way. Processes governed by quantum mechanics are irreducibly unpredictable leading most scholars to conclude that not only is the future unknowable in practice, it is undetermined in principle, as indicated by the famous Heisenberg uncertainty principle. Still, Hawking seeks to counter this move by attempting to argue that random processes cannot be directed towards the kind of purposes theists want to affirm God has in mind. I do not, however, think Hawking is successful in his counter-move. The relation between a statistical or random process and a non-purposive process is much more subtle than Hawking admits. See Hawking, *op. cit.*, pp 166 and 172.

[21] Hawking, *op. cit.*, p 141.

[22] Robert John Russell, 'Theological lessons from cosmology' in *Cross currents: religion and intellectual life* vol 41, no 3 (Fall, 1991), pp 308–321. See also Robert John Russell, 'Eternally creating time: the relation of time and eternity in light of quantum cosmology' in *Quantum cosmology and the laws of nature: scientific perspectives on divine action* edited by Robert J. Russell, Chris J. Isham and Nancey C. Murphy (Vatican Observatory Press, to be published in 1993).

[23] Hawking, *op. cit.*, p 174.

[24] Hawking, *op. cit.*, p 174.

[25] See the compelling case made by Michael J. Buckley, *At the origins of modern atheism* (New Haven: Yale University Press, 1987).

[26] Recently an international conference was convened at the Vatican Observatory and co-sponsored by the Center for Theology and the Natural Sciences, Berkeley. The specific goal was to study the theological and philosophical implications of quantum gravity, including the Hawking model. The publication of the results of this conference is targeted for 1993.