



CTNS BULLETIN

The Center for Theology and the Natural Sciences

Volume 8 Number 1

Winter 1988

BEYOND THE LIMITATIONS OF BIG BANG THEORY: COSMOLOGY AND THEOLOGICAL REFLECTION

Wim B. Drees*

1. Introduction

In this article I will explore issues in theology-and-science in the context of that contemporary scientific cosmology which goes beyond standard big bang theory. In focusing on the content of current research I take an unusual approach¹ to the 'science-and-religion' discussion. It aims at exploring the possible meaning of theological concepts in the context of specific scientific theories. In that way it is independent of 'critical realist' views of science and of theology, as advocated by E. McMullin (1984), I. Barbour (1974), and A. Peacocke (1984). Besides, it offers a two-way view of interactions between theology and science. Too many in this field restrict themselves to the past (e.g. focus on Kepler or Einstein) or to the scientific consensus (big bang theory, evolutionary biology, geology), or methodological issues. Others leave the realm of theories and focus on the misuse of science in society.

In my view, the part of science to be discussed is relevant to three different enterprises:²

- the, mainly philosophical, reflections on the relations between science-and-religion;

- theology done in a world intellectually dominated by science;

- science and philosophy of science done with an eye open for theological and metaphysical issues.

In each of these fields, the present article will pose a number of issues for further reflection (sections 4-6). The article concludes with a section (7) on the usefulness and limitations of the notion "consonance" as a characterization of a fruitful relation between science and theology.

The "data" for this article are theories in current astrophysical research. After pointing out some limitations of the standard big bang theory (2.1), some ideas about the initial conditions of the Universe (2.2) and about the origination event (2.3) will be presented in a non-technical way. One example, the Hawking-Hartle quantum cosmology, is presented in more detail (3.1). Its implications for the Augustinian idea of the creation of time with the world, for *creatio ex nihilo* as God sustaining at every moment, and for the notions of contingency and time are discussed in 3.2. It is essential to the approach advocated in this article to go into the details of a

* Wim B. Drees was a Visiting Fulbright Scholar at CTNS during the fall semester 1987. A native of the Netherlands, he is spending the spring semester at the Lutheran School of Theology at Chicago, studying with former J.K. Russell Fellow Philip Hefner.

Wim is working on his thesis this year. He is concentrating on recent astrophysical theories about the universe (after 1970) and Western religious convictions, including Christianity and its atheistic offshoots. He expects to complete the thesis and trials for ordination next year.

From his studies in the Netherlands Wim has the equivalent of two Masters degrees. His first paper was on the Higgs boson, a particle which occurs in many theories of elementary particles, but which has not yet been detected. His second paper criticized popular views on science and religion today, as present in the works of F. Capra, G. Zukav, and P. Davies.

This article grew out of a talk on his research, delivered at the CTNS Forum on November 17, 1987.

(c) 1988 by Wim B. Drees. Reprinted with the permission of the author.

specific theory and explicate the meaning and limits of certain theological ideas.

2. Scientific Cosmology beyond Big Bang

2.1. Limits of Standard Big Bang Theory

The big bang theory arose out of Einstein's theory of general relativity (1915) and Hubble's discovery of the recession of almost all galaxies (late 1920's). It describes our Universe as expanding from an infinitely dense and hot point, "the Singularity". This expansion began ten to twenty thousand million years ago. A major competitor was the steady state theory, advocated by F. Hoyle and others. This theory assumed that the universe had not changed in its large structure. The big bang theory gained wide support in the 1960s, especially with the discovery of the cosmic background radiation. The big bang theory explains the relative abundances of the lighter elements, like hydrogen and helium. The interested reader is referred to a large number of introductions, like Steven Weinberg's The First Three Minutes (1977).¹ This title suggests that the Universe had a beginning and that we can describe its processes right from the beginning. A closer look reveals that there is a problem, in any case with the second claim, as is generally acknowledged by cosmologists, including Weinberg.

The standard theory is a combination of two different theories: (a) general relativity about the space-time structure of the universe, and (b) quantum theories about matter, describing processes happening to the contents of the Universe. There are three limits to the big bang theory: (i) The theories about matter (b) are only known under circumstances different from those during the first fraction (one ten-thousandths or much less) of a second after "the Singularity", the initial moment which follows from general relativity (a). The term "big bang" is used in the literature both for the moment where the standard theory begins, i.e. a moment much less than a second after the initial singularity,

and for the Singularity itself. (ii) Even closer to the Singularity, there comes a moment, the "Planck time", when general relativity (a) should be replaced by a quantum theory of gravity. (iii) A third limitation is the initial Singularity itself, where the physical theory reaches a more definite limit, at least according to the standard theory.

The big bang theory assumes some initial conditions, like large scale homogeneity peppered with just the right amount of inhomogeneities to produce galaxies; the ratio of amounts of the different particles; the absence of anti-matter and exotic particles; and the density. Some of these conditions are even more peculiar than they seem, due to the 'horizon problem': different regions which we observe in different directions cannot have been in causal contact during the whole past history of the universe, and yet they look very similar. Besides those initial conditions, the big bang theory also assumes general features of the Universe: the laws of physics, the three spatial dimensions and one time dimension,² and the actual existence of the Universe.

The challenge for physicists is to explain those assumptions and to extend the domain of validity of the theory. In the following some approaches will be characterized, focusing on the initial conditions and the Singularity as an (apparent?) origination event.

2.2. The Initial Conditions of the Universe

With respect to initial conditions in the big bang theory, there are at least three different approaches:

(1) Chaotic cosmology explains them by claiming that the initial conditions of the big bang could have arisen from almost all possible initial conditions, so "anything goes." The most recent version stresses that the universe underwent a period of very rapid inflation shortly after the Singularity ("long" before the big bang as the beginning of the standard theory). As this dilutes the universe enormously, "it appears to allow a wide variety of starting configurations" (Guth 1982, 35;

1983, 183). Such inflation is believed to be "a natural and may be even inevitable consequence of the chaotic initial conditions in the very early universe" (Linde 1983a, 180). It is as on a sandy beach, almost any initial condition with or without structures like sand castles will result in a similar smooth beach after some time with wind and tides. The crux of this explanation is that there is a random choice among the possible initial conditions and that almost all choices would lead to a universe like ours.

(2) The absence of boundary conditions, and hence the absence of choice, is the proposal of the Cambridge cosmologist S.W. Hawking. "If spacetime is indeed finite but without boundary or edge, this would have important philosophical implications. It would mean that we could describe the universe by a mathematical model which was determined by the laws of physics alone" (Hawking 1984, 358f.). This will be discussed in more detail below (3), as it also poses an interesting view of the "initial event" and the notion of time. This scheme seems to imply that a universe must have a period of rapid inflation. However, it does not incorporate the "chaotic" philosophy.

(3) The initial conditions were special, according to the Oxford cosmologist R. Penrose. Let the points of a space W represent the possible initial conditions. "Imagine the Creator, armed with a pin which is to be placed at one spot in W thereby determining the state of our actual universe" (Penrose 1981, 248). Penrose then calculates that the Creator must have been very accurate to get initial conditions like ours, for according to his calculations, ours are of a kind which is very very rare among the whole set of initial conditions. "Without wishing to denigrate the Creator's abilities in this respect, I would insist that it is one of the duties of science to search for physical laws which explain, or at least describe in some coherent way, the nature of phenomenal accuracy that we so often observe in the workings of the natural world. ... So we need a new law of physics to

explain the specialness of the initial state" (Penrose 1981, 249). His proposal for a law which restricts initial singularities would do two other jobs as well: it introduces an arrow of time in physics and it might solve the interpretation problem of quantum mechanics.

2.3. The Origination Event

In current scientific literature, there are a number of ideas about a physical description of the Singularity which provide a way of avoiding such an "initial" moment where the known laws of physics appear to break down. I will describe some major 'types.' They all use the recent conclusion that the universe might be equivalent to a vacuum in that there are no cosmically conserved physical quantities like electric charge or energy which have a non-zero sum over the whole universe.

(1) No origin, but an eternally oscillating universe: At least one cosmologist, M.A. Markov, defends the idea that the beginning of the present phase of expansion followed a previous phase of collapse. The original objection (Tolman 1934) was that entropy would increase through the cycles and therefore there could not have been an infinite past. In Markov's scenario (e.g. 1983a,b, 1984) the universe in an early stage had no matter content and so entropy is undefinable. Entropy increase would be something within each cycle. The major advantage of this model is stated as: "In a perpetually oscillating universe there is no problem of origination of the world, which in other versions of the universe might appear to be unsolvable" (Markov 1983a, 353). One could interpret this scheme as the 'creation' of matter in a pre-existing eternal space-time framework. The following idea is basically the same, but now some space-time is set apart.

(2) "Mother" and "child" universes: The Singularity might be seen as the moment of birth or conception--the beginning of time from the perspective of the child, but an event in time from the perspective of the mother. One version is that our Universe is a bubble

within an embedding universe (space-time).³ This is problematic, as children tend to fill (and thereby kill) their mother (Linde 1983b). A second possibility fares better: a mini-universe appears as a bubble on the "surface" of the mother, after evaporation of the connection it becomes spatially disconnected, like a child after birth. According to a Japanese group this has the peculiar consequence that "although the Creator might have made a unitary universe, the universe itself is also capable of bearing child universes, which are again capable of bearing universes, and so on" (Sato et al. 1982, 106). According to their calculations, one universe might have as many as 10^{77} child universes. The idea appears promising, but is not well developed.

According to these approaches there is no absolute beginning. Many cosmologists working in this field defend a third approach, a beginning of the Universe with time. The idea of quantum creation, discussed below, seems to be the most fruitful.

(3) Appearance out of nothing: In the last few years, a number of articles⁴ have appeared in major physics journals with titles as "Creation of Universes from Nothing" (Vilenkin 1982). Most proposals describe it as a quantum effect, which occurred by chance. There are some criticisms, especially focusing on the "nothing" assumed in these ideas (Linde 1983b, Drees 1987). The "nothing" is already on the side of physical existence, although a strange entity like metric without volume. One can think of the quantum probabilities for this case as being similar to those when throwing dice: the chance of getting an odd number is fifty percent, but that assumes that there is a die which is thrown. So the reality of the die (and the dice factory) and the reality of the throw are assumed. Even if one does not agree with a complete philosophical *ex nihilo* interpretation of these proposals, they do relate to traditional metaphysical questions, like "why the universe is as it is?" The next section is devoted to one of the most promising proposals of this kind, that of Hartle and

Hawking.

3. Quantum Cosmology and *Ex nihilo*

3.1. Outline of a Scientific Idea

The following is a very simplified non-technical description of the proposal of Hartle and Hawking (1983), using an unpublished paper by C.J. Isham. The latter article is also interesting as Isham explicitly presents it as an aid to discussing the similarities and dissimilarities between scientific and theological perspectives on creation (more in 3.2).

(1) The basic entities of the world are, in this theory, curved three dimensional spaces or geometries g filled with matter fields f , $(g,f)_3$. Instead of having one four dimensional space-time as in general relativity, the universe is now described as an infinite stack of slices. The basic entity of the theory, as in other quantum theories, is a wave function which gives the probabilities for the different $(g,f)_3$'s.

(2) There is no external time parameter in this theory. Each $(g,f)_3$ can be split into two parts, one part defining the value of a time parameter for this $(g,f)_3$ and the other part describing the physical features due to curvature and matter.

(3) The theory admits of calculations of the probabilities along two different lines:

(A). One can think of the $(g,f)_3$'s as describing an evolving system. One can take a certain three dimensional space as the initial state and calculate the probabilities for all future states arising from that one. This description from within time is described by a differential equation, the Wheeler-DeWitt equation. Disadvantage of this approach is that one needs to specify a boundary (or initial) condition. Therefore, this approach does not help very much in discussing the 'creation' of the universe.

(B). The interesting feature of the Hartle-Hawking proposal is that one can also calculate the wave function giving the probabilities for the $(g,f)_3$'s directly, without referring to other states or to evolution from

such other states. This part of the proposal is the most technical, as it needs the formalism of path integrals and a notion of imaginary time, but it seems to work. The only condition is that the three spaces g_3 are closed, like a two dimensional surface of a balloon is closed in a three dimensional world. In this sense, this scheme assumes that our Universe is closed.

(4) The timeless level of calculation is in this theory more fundamental than the description within time (A). It is as if one can calculate the probabilities of all the different slices and then put them together as stacks which resemble a four dimensional space-time like our big bang universe.

It should be noted that this theory does not produce just one stack, i.e. one big bang universe. The slices form a whole variety of such stacks (corresponding to possible evolutionary sequences of three dimensional geometry and matter configurations in a universe). The interpretation of all these possibilities--whether to ascribe ontological status to them or assume the reality of only one--is not clear. As far as I can see, most defenders of this scheme adhere to the Many Worlds Interpretation, ascribing equal ontological status to all these stacks and all $(g,f)_3$'s (Hawking 1984). Isham takes the scheme only as meaningfully "predicting" when the probability is one, hence when something "happens" in all "stacks".

(5) As the calculation on the timeless level proceeds without initial conditions, it lends itself to the interpretation that each $(g,f)_3$ arises from "nothing". Combining this with language from the A level (time), this scheme is claimed to describe probabilities for "tunneling from nothing". I hold the latter phrase to be confusing and unclear because of the mixture of two descriptions. "Tunneling" connotes a temporal process, whereas, in this theory, "from nothing" applies to a time-independent actuality.

(6) In this scheme time is an internal feature, a phenomenological construct out of the $(g,f)_3$'s. If one uses this scheme for spaces

which are close to the "beginning" of the Big Bang universe, i.e. small closed spaces, one expects to approach the interesting " $t=0$ " moment at the initial singularity. However, in this scheme the "internal time" becomes more and more unlike our ordinary time. In mathematical language, it picks up an imaginary component. The smaller one takes one's three-geometries, the more the imaginary part of this "time" becomes dominant. In this way, the theory has no "initial singularity" where the theory breaks down. Only the interpretation in terms of our usual notions of time breaks down.

3.2. Theological Reflections on This Theory

C.J. Isham relates the Hartle-Hawking theory to the question discussed by Philo of Alexandria and Augustine⁵ about God's relation to time, especially to time with creation, and to the notion of *creatio ex nihilo*. He also stresses that this scheme eliminates partly the element of choice or acausality which in the big bang theory is connected to the initial singularity. I will discuss these three issues and conclude with some remarks about theological schemes to which this approach would fit. Before discussing such theological reflections, however, it needs to be said that there is nothing within this scheme of quantum creation that provides an argument for a preference of a theistic over an anti-theistic, say materialistic, interpretation.

"What was God doing before the creation of the world?" The solution given by Augustine and Philo⁶ was that the question is meaningless, as time was created with the material world, or perhaps--according to Philo--even later, when movement started. As Isham points out, this is in its basic idea similar to the notion of 'internal time', arising as a construct out of the slices of space and matter, used in this theory. Within the scheme it becomes meaningless to ask about times without such spaces.

Traditional theological ideas about *creatio ex nihilo* have two poles. On the one hand they refer to cosmogony, the coming into

being of our Universe. On the other hand they denote an eternal sustaining, ultimate dependence at each moment. Isham states that the latter is 'somewhat decoupled from modern scientific thought', which I think is a widely held view among both theologians and scientists.

In my view, the theory discussed here lends itself much more to an interpretation in terms of "sustaining" than of "making". The basic entities of this theory are the three dimensional spaces with material content. Therefore, these are to be seen as the basic entities of creation--the "what" that is created. Their characteristic probabilities can be calculated on the timeless level. Therefore, they are created "timelessly"; they are, from the timeless perspective, co-eternal with one another. There is no sense in which one slice is produced by another, unless one goes to the description from within time.

Another way to argue for the same conclusion: this scheme does not have an initial event with a special status. Hence, all moments have a similar relation to the Creator. Either they are all "always there" as a brute fact, or they are all equally created.⁸

It is a nice feature of this quantum cosmology that that part of the content of *creatio ex nihilo* which was supposed to be the most decoupled from science, namely the "sustaining", can be seen as the more natural part in the context of this theory. The actual line of argument raises questions about the relation between the two components of *creatio ex nihilo*. Understanding it as about a cosmic process seems to single out a certain event as having a special relation to God. Sustaining tends to stress the similarity of all states in their relation to God. For theologians who want to defend both components of *creatio ex nihilo* this presses the necessity for clarity on the similarity and dissimilarity between the initial and the later states in their relation to God. In the Hartle-Hawking quantum cosmology there is no moment with a special status, and therefore the cosmogonic interpretation of *creatio ex nihilo* loses its force.

Isham emphasizes the contingency (my wording) of the standard big bang theory in that it is unable to predict the evolution of the universe from the initial singularity. There are many possible futures arising from that singularity. The theory is "dualistic" in making a distinction between the laws and the boundary conditions, the latter picking one of the possible solutions of the laws. It is only after the singularity that the evolution is causal and deterministic. According to Isham, the Hartle-Hawking quantum cosmology removes some of that acausality in the description of the world.

However, there is a problem. The quantum cosmology ascribes probabilities not just to one "stack" of three-spaces, but to many such "stacks". Therefore, the function of the boundary conditions--picking one solution out of many possible ones--is in a way still there. But this is dependent on the interpretation of the probabilities, more general: the interpretation of quantum mechanics. If one accepts the Many Worlds Interpretation all stacks are there. The "choice" disappeared, but at the price of including many "worlds", in this case stacks of three spaces. Because there are no boundary conditions and no "choices", everything is necessary, given the scheme, which takes on the character of a package deal.

If one rejects the Many Worlds Interpretation--if one does not want to ascribe similar ontological reality to all possibilities--almost the same contingency as the one related to the big bang singularity is there: there is no way within the theory to determine which stack is the "actual" one and hence no explanation why the Universe is as it is.

Isham argues for a third interpretation: take only the "predictions" which have probability one--which are certain to happen in all stacks or worlds. These are the only genuine "predictions". One such prediction seems to be that universes have inflationary phases, and hence many of the features (homogeneity, flatness) observed to be the case in our Universe. Interpreted this way the

Hartle-Hawking theory removes some of the contingencies of the big bang theory. But it also implies that quantum cosmologies are limited, as other probabilities, which are not one, cannot be interpreted meaningfully.

There remain also other contingencies, although at a different level. They are partly mentioned by Isham as assumptions of this theory. Adapting a scheme of R.J. Russell (1987, 1988a,c) I distinguish three types:

a. ontological contingency: why is there anything at all? Why is there a referent for this mathematical scheme? This is the reality of the dice and the throw described above (2.3.3).

b. nomological contingency: why are the laws which are used to describe the features of the matter (superstrings?) what they are? Could one not have a different set of laws?

c. existential contingency: why this scheme and not another one, like that proposed by Vilenkin? Or Penrose's twistors instead of space-time?

It is, of course, feasible that a future theory might remove the contingencies b. and c., for instance by showing that these are the only consistent possibilities. This is quite a high goal, but something like that seems behind G. Chew's bootstrap program. However, at the level of the theory described in this chapter, these are remaining contingencies even aside from the interpretation problem of the quantum probabilities.

As pointed out to me by C.J. Isham, the existential contingency--why this scheme and not another--is different from the preceding contingency in initials conditions or "stacks". In the set of possible initial conditions (or "stacks") we assume that there is no a priori difference between the one and the other; they are all equally probable. Therefore, an explanation could only remove this contingency by showing that a certain feature results for each of the possible initial conditions, or by stepping outside the theory which implied this set of possible initial conditions. In the set of possible theories there are other

criteria for choice, like beauty, simplicity and coherence. Not all apparently consistent theories are attractive to us, and presumably this also holds for the Creator. The contingency of theory choice is thereby not removed, but is of a different nature than the other one, as there are criteria for theory choice (see Lakatos 1978 for one description of such criteria). Criteria will be more applicable between theories which are similar in their basic outline, like Hartle-Hawking's and Vilenkin's quantum cosmology than in deciding between very dissimilar theories, like the twistor approach of Penrose and the Hartle-Hawking cosmology (Drees 1988).

Looking for a theological scheme "consonant" with this quantum cosmology, it is clear that theologies with a strong emphasis on development in time do not fit. A major example of such theologies is Whiteheadian process theology, which is in general assumed to be in its metaphysics in line with much of modern science. Among many, some other examples of such theologies are in the works of A.R. Peacocke (1979, 1986), I. Barbour (1988), and J. Moltmann (1985).

Amazingly, the theory presented in this section seems much closer to two seventeenth century views. It seems consonant with traditional Reformed theology which saw everything--both sin and salvation--as predetermined by God (predestination). It also appears to be consonant with a Spinozistic view of God and the world--where the world is one of God's eternal modes of being. As traditional Reformed theology, this view accepts a strict determinism. In a sense, the Spinozistic view fits even better, as the Universe in the Hartle-Hawking scheme acquired some of God's characteristics, being 'eternal' and 'necessary'.

The theory described in this section has one major problem if related to a Christian view of the world. In the way I construe it, the theory is about an infinite set of independent three-dimensional spaces with content. This breaks completely the continuity between "subsequent" events, like the

reading of the first and the second half of a sentence.

The presence of two levels of description, one timeless and one within time is quite common in physics. For instance, the evolution of a system (in time) can be described by a whole trajectory (whole history at once) in state space. The peculiar feature of this quantum cosmology is that the timeless description is not about the whole history of the system, but about the individual slices of "now". In that sense, the timeless description undermines the sense of continuity between the "subsequent" slices more than other "timeless" theories in physics do.

In this case, one might invoke God as the one who gives the continuity, but that seems a bit like God "closing the gap", to turn a phrase. In the major lines of Christian thought there is a sense of history and continuity, as God's great deeds in the past (e.g. Exodus, covenant on Sinai, Incarnation) are supposed to have relevance today and for the future. In that sense, the past has to be taken up into the present in some way.

Perhaps this problem of continuity might be resolved by considering the implications of the fact that there are different ways to divide the (g,f)3's into a part defining internal time and a part describing the physical phenomena. This is somehow similar to the possibility of having different ways of dividing four dimensional space-time into three dimensional spaces and a time parameter. As different slicings place different events in the same slice, the coherence increases this way. If that would be sufficient to make the whole stack, the four dimensional space-time, more fundamental than the slices, that would be sufficient to restore continuity between past, present and future.

Another problem which will be as serious for most theologians is the deterministic character of this theory, not allowing for anything like free will and responsibility. However, this is typical of many physical theories. And it is not part of all Christian theologies, for instance not of the

predestination version of Reformed theology.

A final word of caution: this theory is only one example of ideas discussed in the scientific literature today, although one of the most elegant and coherent schemes. It is not to be taken as the conclusion of science today, although many features are inherent to all quantum cosmologies and not only to the Hartle-Hawking theory. As I have showed in the preceding section (2) there exists quite a variety of ideas, both on initial conditions and on the initial event, as well as on the laws of physics. These have different possible implications in themselves. I would like to point briefly to some implications of this situation with a plurality of ideas, both for the dialogue between science and religion, for theology itself, and for scientists who want to take these matters seriously.

4. Implications for Science-and-Theology

There are a number of items in discussing the relation between science and religion that I think can be raised in the context of scientific ideas beyond the big bang theory. The following is an agenda, suggesting future work.

(1) The influence of religious convictions on the formation and justification of such scientific ideas. Religious language is used in some scientific articles (e.g., the Creator choosing, *creatio ex nihilo*). Aside from the language, some of the expressed goals are related to a certain worldview, which has clear, if unstated, religious impact; for instance, in trying to evade an initial event or any element of choice in this event. It would be interesting to see whether there could be found any pattern in the geographical and religious (Western, Japanese, Soviet Union) diversity of contributions.

A wider aim of such work would be to see how this influence of religious and metaphysical convictions on the scientific work can be incorporated into better descriptions of science, for example, in views in philosophy of science on the formation of theories. I think that in Lakatos' methodology

of scientific research programs (Lakatos 1978), the positive heuristic is the place to locate such influences (Drees 1988).

(2) Although many in the "science and religion" field stress the relevance of methodological issues, the preceding section shows that some current work is also interesting for its content. For instance, Hawking has a quite different view of the nature of time than Penrose, which implies a different view of history and processes. This might bear, for instance, upon ideas about the relation between God, time, and the world, and upon notions as contingency and necessity.

If the interesting metaphysical questions are for the moment not in the established big bang theory but at the forefront of research, what is the relevance of established scientific theories for the science and theology interaction? And how does theology deal with the variety of views suggested by the different approaches: Choose the one that fits best the existing religious view, or wait until there is scientific consensus, or try to express its own view in terms of as many different approaches as possible?

(3) The variety of ideas under discussion also raises questions about the status of such ideas and their relation to 'reality', i.e. about "scientific realism" (McMullin 1984). There are of course a number of possibilities, like:

a. One of them could turn out to be triumphant, so the "true" one.

b. It could happen--as happened for different formulations of quantum mechanics (wave functions or matrices)--that the different approaches are equivalent.

c. It could be that we have a couple of theories which are in accordance with all available data but are conflicting in their theoretical structure.

The first possibility would be a support for a sort of realist interpretation of science. The second also, although it would have peculiar consequences. If, for instance, it could be shown that Hawking's program and Penrose's program are in some sense equivalent, then

that would imply that one could describe the world both as having a fundamental arrow of time and a beginning, or as lacking a universal notion of time and its direction. It is as if one could describe the world physically both from God's point of view, *sub specie aeternitatis*, and from within the process. However, I think that this equivalence will not come out of these programs, as they are too far apart. Perhaps differences will show up most clearly in their view of the long term future.

The third option would support the idea of "underdetermination" (Hesse 1980, 1983), which is that theories are "underdetermined" by their data, so allowing for a variety of theories compatible with the same data. Similar varieties are, I suspect, present elsewhere, especially in relation to such metaphysical items as causality, the relation between mind and matter, and the ontology of matter and space-time.

There is a danger in overemphasizing the divergence in scientific research in the context of science-and-religion, as it might suggest that almost all views are as good. There is also coherence in science. For instance, all these examples discussed in this article do accept the standard big bang theory within its limits. And they all have certain criteria and data they agree upon. In these senses, the scientific zoo shows less variety than the (anti)theological and religious zoo.

(4) If, as I suspect, we will have to live with some conflicting but scientifically defensible cosmologies, what would that imply for our opinion on the status of religious ideas? Do they display a similar kind of pluralism, being compatible with some experiences but nonetheless different? If so, it would be worthwhile to present them in a way which most clearly exhibits the differences and similarities.

In short, the presentation of developments in scientific cosmology in the preceding sections show

- the relevance of content aside of method;
- the limited relevance of theories

about which there is consensus (like the big bang theory), as the interesting issues turn up again just beyond the border of its limitations; and

- the inherent pluralism (although many workers in the field adhere to the Hartle-Hawking theory and similar quantum cosmological ideas) in metaphysical ideas in contemporary cosmology, which raises questions about convergence-arguments for critical realism.

5. Implications for Theological Agenda

(1) The most general question is: can we express theological statements in the language of these theories? I would like to emphasize that I do not want to derive any theological conclusions, but consider "expressing" a reasonable aim. Can we use the language of these models as languages in which to express our worldview, including its religious notions? To do this is essentially to go into the content of these theories, as different theories offer different "languages" with different possibilities for expressing certain ideas. An example of what I mean with this question is offered above, when I showed how the Hartle-Hawking theory might be used to express the "sustaining" part of the doctrine of creation, as well as reflected on the way "contingency" could be seen in relation to this theory.

(2) A general feature of many physical theories is the presence of two levels of description, within time as an evolving system, and timeless, as given by a whole trajectory (history) of the system at once. Aside from the specific problem with the Hartle-Hawking proposal, as it lacks the continuity of a history in its timeless description, this general feature might be something worth reflecting on. Many theologies (e.g. process theology, Peacocké, Barbour and others) discuss only the dynamic interpretation, the description as a process. If one takes the presence of these two levels of physical description as revealing something about "reality", these theologies appear to be too one-sided. Might it be that

one could express theological ideas also in two ways, say from within time--emphasizing God's activity--and from beyond time, stressing God's being? Or perhaps one can more appropriately apply it not to our thoughts about God, but to those about the world, which can be seen from within as evolving or from God's point of view, *sub specie aeternitatis*, as present as a whole? Might one also associate this with the differences within the Old Testament between prophetic literature (within time) and wisdom literature?

(3) In the context of cosmological theories, I think that the doctrine of creation and God's relation to time is the major area for further reflection along the lines sketched in this article. To mention a few catchwords: creation as finiteness, both spatially and temporally (Russell 1987, 1988a); the use of spatial and temporal metaphors, as incarnation, body of Christ, and its relation to space-time as a container or relational, tied up with material creation (Torrance 1969, 1976); providence and process, determinism and freedom; sustaining at all moments and a special moment of creation; contingency, God's freedom in creating; the reality of time and the qualitative difference between past and future.

(4) The preceding presentation bears also upon the use of empirical elements in cosmological arguments for the existence of God. A temporal version, based on a beginning of the Universe a finite time ago, as defended by W. Craig (1979), is not supported by 'science'. It appeared to be supported by the big bang theory, but at the next level all options are open again. One might defend again an infinite past, either as oscillating (Markov) or as a mother giving birth to 'children' which appear to have a finite past. The major quantum cosmology discussed above seems to imply a finite past, but without allowing one to point out a first state. It is not amazing that philosophers and theologians do not know about all such ideas, but it is a serious failure for them to neglect the limits of those scientific ideas which they do use. Such

limits for the big bang theory were clear when Craig wrote his book.

A more subtle non-temporal version of the cosmological argument, arguing that the whole (perhaps infinite) series of states needs an explanation, has been defended by R. Swinburne, among others. The present cosmological theories do not affect his argument that we ultimately have to face two possibilities: 'The choice is between the universe as a stopping-point and God as a stopping-point' (Swinburne 1979, 127). However, his argument for preferring God as the stopping-point rests on the claim that "God" is a much simpler assumption than the universe alone with all its complexities. Scientific theories about the universe might be of an impressing elegance and simplicity, and hence suggest that those theories are a simpler stopping point than "God".

(5) As I suggested when interpreting the Hartle-Hawking theory, there might be other worldviews which can also be interpreted in these languages. Theologians tend to face two alternatives, either a theistic or an atheistic interpretation, but they should be more subtle in considering Spinozism, Pythagoreanism and others as equally interesting rivals at the metaphysical level. Although they might be far removed from other parts of experience, at least at the level of reflections on the expressibility of different religious views in scientific languages they are viable alternatives.

(6) The plurality of theories in contemporary research (see 2.2 and 2.3) raises questions for critical realism as the basis for the relation between science and theology (defended by Barbour 1974, Peacocke 1984). Which theory refers in which of its aspects to reality? Or are they all compatible with reality, as 'underdetermination' suggests? The defenders all use realistic language, so, although faced with a plurality, most of the scientists involved hold implicitly a realist view of their theories. For the theologian this presses the need for reflection on the status of theological statements, especially in what

sense they can be said to refer. And if a theologian gives up on the reference to reality, in what sense do they still have meaning? And how can these ideas than give comfort?

(7) I would like to point to some more general questions, which are beyond the limits of this kind of inquiry. A major question is whether we, as humans, are in a sense "at home" in the universe. Is there resonance or dissonance between our existence and the universe (Hefner 1970)? And would dissonance mean the end of theology by undermining God's trustworthiness--as Hefner seems to have it--or can we still do theology, although perhaps in a much more existential way, aware of Pascal's feeling 'Les espaces infinis m'effraie'--"the infinite spaces terrify me". In reflecting on resonance or dissonance in relation to cosmology, a problem is the immensity of our Universe with the possibility of intelligent and moral life elsewhere. This raises questions about human nature as 'crown of the creation' and about the uniqueness of Christ. Prospects for the far future, with scenarios of either another big crunch or a freeze raises questions for eschatology and purpose in the creation.

6. Implications for Scientific Agenda

In the preceding section I considered theologians who wanted to take science seriously. Similarly, one could discuss the implications for scientists who want to take theology seriously. A few remarks:

(1) Scientists could help the theologians in their work, as described in the preceding section, by clarifying the scientific ideas and the philosophical elements in science. I would especially point to the existence of evolutionary and timeless descriptions in some physical theories.

(2) I do not believe in explicit guidance, like saying to a Reformed scientist that he should work in a specific program and not in others. There is enough intelligence and creativity within the scientific community. Besides, a program which at first seems dis-

sonant with a certain religious view might in the long run turn out to be much more consonant with it than expected.

However, I think that those who want to take seriously the philosophical dimensions of science should try to clarify their implicit philosophical and religious motives in pursuing a certain approach and rejecting another one, i.e., their criteria of theory choice. This is an appeal to enter a conversation on those metaphysical components in science.

7. The Limits of "Consonance"

The notion of "consonance", introduced by E. McMullin (1981) and developed by T. Peters (1988) and R.J. Russell (1987, 1988a), has been used as a metaphor for the possible "fit" between a certain scientific theory and a certain religious or theological view of the world in relation to God. "Consonance" has two great advantages: it takes both parties seriously, including also their wish to be independent; and it can allow for different combinations, as one scientific theory might be consonant with more than one religious view. However, it is not completely satisfactory in the light of the scientific theories discussed above. It suggests too much an autonomous individual who is standing between the scientific and the religious community, listening to both sides and declaring harmony. As such, it is similar to the bridge metaphor, where science and religion are seen as independent, externally related.

1. As I have hoped to show in this article, they are much more internally related. Within the various scientific lines of approach there are different metaphysical views already present. Within the theological ideas, for instance about God's relation to the world and to time, there are many implicit scientific assumptions. Or at least they are needed to make the ideas intelligible by relating them to "empirical content".

This might be related to a constructive use of "consonance" instead of using it as a descriptive term. As first pointed out by R.J. Russell, by assuming consonance the abstract

theological or philosophical concepts acquire a more specific meaning as they get related to empirical matters and a wider body of ideas (Russell 1987, 1988a). This is what happened to *creatio ex nihilo*, time as a created entity, and contingency in the quantum cosmology discussed above. The limits to such concepts, limits at least in the context of specific scientific theories, might also become more clear.

2. The "consonance" metaphor assumes that both scientific theories and theological concepts are intended to be descriptions of the world. In light of the different research programs I have some problems with realism, and with belief in convergence toward the correct description. Besides, this article shows that it is unnecessary to restrict the dialogue between theology and science to the 'sort of theory on which the realist grounds his argument' (McMullin 1984, 17), namely those which have an increase in internal structure over a long period. Therefore, I would plead for a more modest consonance, where it is restricted to theories and concepts therein.

3. "Consonance" is also rather vague. It seems as if any religious conviction and any scientific theory could be taken together as consonant, if one adds sufficiently ingenious auxiliary hypotheses. Therefore, it needs to be supplemented with criteria to distinguish genuine consonance from *ad hoc* constructions. This would be something similar to the search for criteria to distinguish progress in science from *ad hoc* adaptations (see Lakatos 1978).

It is as with the relation between the economy and the stock market: the relation is not something external, added afterwards. But neither is it straight, direct determination, since there are many other factors involved.

Perhaps, although also somewhat external, the notion of "dressing" might provide a fruitful metaphor for science and religion. There is a Dutch proverb: "Clothes make the person". There might be different clothes that fit one person, but not all clothes fit a certain person as nicely. Persons, as

social beings, are always dressed. Even a naked person would by his or her nakedness be a specific social person, fitting for some occasions but not for others. In general, the fit between clothes and body is also dependent on the context and the role the person plays in that context. Similarly, a doctrine of creation is always dressed up (implicitly sometimes) in a worldview and thereby in terms related to scientific theories. However, the essential characteristics are not dependent on the way the doctrine is dressed up, although they can be hidden and get lost from sight. Consonance would be like fitting clothes, those that accentuate the characteristic features of the body (form, color of skin and hair, etc.) and fit for the occasion.

ACKNOWLEDGMENTS

The author wishes to thank R.J. Russell for the hospitality at the Center for Theology and the Natural Sciences during the Fall of 1987, and for the sharing of ideas. He thanks C.J. Isham for permission to use his paper and for many valuable comments, which saved him from some errors. He also thanks T. Peters for supporting the dressing metaphor.

These investigations were supported by the Foundation for Research in the Field of Theology and the Science of Religions in the Netherlands, which is subsidized by the Netherlands Organization for the Advancement of Pure Research (Z.W.O.). The author is also grateful for a Fulbright scholarship and additional financial support from several Dutch funds.

BIBLIOGRAPHY

- Atkatz, D., H.R. Pagels. 1982. 'Origin of the Universe as a Quantum Tunneling Event.' *Phys.Rev. D* 25:2065-2073.
- Barbour, I.G. 1974. *Myths, Models and Paradigms*. New York: Harper and Row.
- Barbour, I.G. 1988. 'Creation and Cosmology.' In *Cosmos as Creation*, ed. T. Peters, (forthcoming).

- Brout, R., F. Englert, E. Gunzig. 1978. 'The Creation of the Universe as a Quantum Phenomenon.' *Ann.Phys.(N.Y.)* 115:78-106.
- Brout, R., F. Englert, P. Spindel. 1979. 'Cosmological Origins of the Grand-Unification Mass Scale.' *Phys.Rev.Lett.* 43:417-420.
- Brout, R., F. Englert, J.M. Frere, E. Gunzig, P. Nardone, C. Truffin, Ph. Spindel. 1980. 'Cosmogenesis and the Origin of the Fundamental Length Scale.' *Nucl.Phys. B* 170:228-264.
- Craig, W.L. 1979. *The Kalam Cosmological Argument*. London: Macmillan.
- Davies, Paul. 1984. *Superforce: The Search for a Grand Unified Theory of Nature*. William Heinemann Ltd.
- Drees, W.B. 1987. 'Interpretation of the Wavefunction of the Universe.' *Intern.Journ.Theor.Phys.* 26:939-942.
- Drees, W.B. 1988. 'Philosophical Elements in Penrose's and Hawking's Research in Contemporary Cosmology.' (preprint)
- Gott, J.R. 1982. 'Creation of Open Universes from De Sitter Space.' *Nature* 295:304-307.
- Guth, A.H. 1982. '10-35 Seconds after the Big Bang.' In *The Birth of the Universe*. Eds. J. Audouze, J. Tran Thanh Van. Gif sur Yvette: Editions frontieres.
- Guth, A.H. 1983. 'Phase Transitions in the Very Early Universe.' In *The Very Early Universe*. Eds. G.W. Gibbons, S.W. Hawking, S.T.C. Siklos. Cambridge: Cambridge U.P.
- Hartle, J.B., S.W. Hawking. 1983. 'Wave Function of the Universe.' *Phys.Rev. D* 28:2960-2975.
- Hawking, S.W. 1984. 'Quantum Cosmology.' In *Relativity, Groups, and Topology II*. Eds. B.S. DeWitt, R. Stora. Amsterdam: North Holland.
- Hefner, P. 1970. 'The Relocation of the God-Question.' *Zygon* 5:5-17.
- Hesse, M. 1980. *Revolutions and Reconstructions in the Philosophy of Science*. Brighton (Sussex): Harvester Press.
- Hesse, M. 1983. 'Cosmology as Myth.' In *Cosmology and Theology*. Eds. D. Tracy, N. Lash. Edinburgh: Clark, New York: Seabury. (= Concilium 1983 (6)).
- Isham, C.J. 1987. 'Creation of the Universe as a Quantum Tunneling Process.' Paper presented at the Study week at the Vatican Observatory on 'Our Knowledge of God and Nature: Physics, Philosophy and Theology', Sept. 21-26, 1987. Will be published in 1988 in, Eds. R.J. Russell, B. Stoeger, G.V. Coyne.

- Lakatos, I. 1978. *Philosophical Papers, Vol. 1: The Methodology of Scientific Research Programmes*. Eds. J. Worrall, G. Currie. Cambridge: Cambridge U.P.
- Linde, A.D. 1983a. 'Chaotic Inflation.' *Phys.Lett. B* 129:177-181.
- Linde, A.D. 1983b. 'The New Inflationary Universe Scenario.' In *The Very Early Universe*. Eds. G.W. Gibbons, S.W. Hawking, S.T.C. Siklos. Cambridge: Cambridge U.P.
- Markov, M.A. 1983a. 'Some Remarks on the Problem of the Very Early Universe.' In *The Very Early Universe*. Eds. G.W. Gibbons, S.W. Hawking, S.T.C. Siklos. Cambridge: Cambridge U.P.
- Markov, M.A. 1983b. 'Asymptotic Freedom and Entropy in a Perpetually Oscillating Universe.' *Phys.Lett. A* 94:427-429.
- Markov, M.A. 1984. 'Problems of a Perpetually Oscillating Universe.' *Ann.Phys. (N.Y.)* 155:333-357.
- McMullin, E. 1981. 'How Should Cosmology Relate to Theology?' In *The Sciences and Theology in the Twentieth Century*. Ed. A.R. Peacocke. Notre Dame: Univ. of Notre Dame Press.
- McMullin, E. 1984. 'The Case for Scientific Realism.' In *Scientific Realism*. Ed. J. Leplin. Berkeley: Univ. of Calif. Press.
- Moltmann, J. 1985. *God in Creation: An Ecological Doctrine of Creation*. London: SCM.
- Moss, I.G., W.A. Wright. 1984. 'Wave Function of the Inflationary Universe.' *Phys.Rev. D* 29:1067-1075.
- Pagels, H.R. 1985. *Perfect Symmetry: The Search for the Beginning of Time*. New York: Simon and Schuster.
- Pannenberg, W. 1981. 'Theological Questions to Scientists.' In *The Sciences and Theology in the Twentieth Century*. Ed. A.R. Peacocke. Notre Dame, Ind.: Univ. of Notre Dame Press. (Also in *Zygon* 16:65-77.)
- Pannenberg, W. 1988. 'The Doctrine of Creation and Modern Science.' To appear in *Zygon* 23 (March 1988).
- Peacocke, A.R. 1979. *Creation and the World of Science*. Oxford: Clarendon Press.
- Peacocke, A.R. 1984. *Intimations of Reality: Critical Realism in Science and Religion*. Notre Dame, Ind.: Univ. of Notre Dame Press.
- Peacocke, A.R. 1986. *God and the New Biology*. London: Dent and Sons.
- Penrose, R. 1981. 'Time Asymmetry and Quantum Gravity.' In *Quantum Gravity II*. Eds. C.J. Isham, R. Penrose, D.W. Sciama. Oxford: Clarendon Press.
- Peters, T. 1988. 'On Creating the Cosmos.' In ..., Eds. R.J. Russell, B. Stoeger, G.V. Coyne, (forthcoming).
- Russell, R.J. 1987. 'Theological Implications of Physics and Cosmology.' Paper presented at the Presbyterian Consultation on the Church and Contemporary Cosmology, December 1987.
- Russell, R.J. 1988a. 'Cosmology, Creation and Contingency.' In *Cosmos as Creation*. Ed. T. Peters, 1988, (forthcoming).
- Russell, R.J. 1988b. 'Christian Theology in a Quantum Theoretic Universe.' In ..., Eds. R.J. Russell, B. Stoeger, G.V. Coyne. (forthcoming).
- Russell, R.J. 1988c. 'Contingency in Physics and Theology: A Critique of the Theology of Wolfhart Pannenberg.' To appear in *Zygon* 23 (March 1988).
- Sato, K., H. Kodama, M. Sasaki, K. Maeda. 1982. 'Multi-production of Universes by a First-order Phase Transition of a Vacuum.' *Phys.Lett. B* 108:103-107.
- Swinburne, R. 1979. *The Existence of God*. Oxford: Oxford U.P.
- Tolman, R.C. 1934. *Relativity, Thermodynamics, and Cosmology*. Oxford: Clarendon Press.
- Torrance, T.F. 1969. *Space, Time, and Incarnation*. London: Oxford U.P.
- Torrance, T.F. 1976. *Space, Time, and Resurrection*. Edinburgh: Handsel Press.
- Trefil, J.S. 1983. *The Moment of Creation: Big Bang Physics from before the First Millisecond to the Present Universe*. New York: Scribner's.
- Vilenkin, A. 1982. 'Creation of Universes from Nothing.' *Phys.Lett. B* 117:25-28.
- Vilenkin, A. 1983. 'Birth of Inflationary Universes.' *Phys.Rev. D* 27:2848-2855.
- Vilenkin, A. 1984. 'Quantum Creation of Universes.' *Phys.Rev. D* 30:509-511.
- Vilenkin, A. 1985. 'Classical and Quantum Cosmology of the Starobinsky Inflationary Model.' *Phys.Rev. D* 32:2511-2521.
- Vilenkin, A. 1986. 'Boundary Conditions in Quantum Cosmology.' *Phys.Rev. D* 33:3560-3569.
- Weinberg, S. 1977. *The First Three Minutes. A Modern View of the Origin of the Universe*. New York: Basic Books.
- Zeldovich, Ya.B., A.A. Starobinsky. 1984. 'Quantum Creation of a Universe with Non-Trivial Topology.' *Sov.Astron.Lett.* 10:135-137.