ARTICLES

COSMOLOGY AND GENESIS: THE ROAD TO HARMONY AND THE NEED FOR COSMOLOGICAL ALTERNATIVES

Mart de Groot
Armagh Observatory
Armagh, BT61 9DG Northern Ireland

WHAT THIS ARTICLE IS ABOUT

The current scientific picture of the origin of the Universe seems at odds with the Genesis account. Is this a serious problem for those who believe the latter to be reliable? Are there ways to harmonize the two? Or should we be looking for alternatives to the so-called Standard Model for the origin of the Universe? This article presents some thoughts that suggest answers to the above questions along the following lines: most of the apparent problems can be solved by realizing that the so-called Standard Model has weaknesses and allows other models and other interpretations; on a number of scores the two accounts can be harmonized, because both leave enough room for accommodating a wider view; on other scores harmony seems impossible, and there is a need for considering alternative cosmologies, especially creation by God.

INTRODUCTION

This article begins with a short discussion of the measurement of long time-scales, followed by a review (Section 3) of the main characteristics of the Standard Hot Big Bang Model. Weaknesses in the Standard Model are discussed in Sections 4 to 7; matters that seem to point to an intelligent design in Sections 8 and 9; scientific ideas about the very beginning of the Universe, i.e., what happened before the time specified in the Standard Model, in Sections 10 and 11. Further reasons for investigating alternatives are summarized in Section 12, and one particular alternative, creation by God, is discussed briefly in the Conclusion.

1) THE MEASUREMENT OF TIME

Astronomers have conclusively shown that the Universe by any standards is very large. Yet, here is tiny man on a rather small planet orbiting a not particularly impressive star. That star, our Sun, is one of some 100,000 million in our Milky Way Galaxy — a galaxy of which there are about as many as there are stars in our Milky Way. This tiny human on this tiny planet has constructed instruments which allow him to study such a large Universe almost as far as it stretches. As our knowledge of the Universe reaches out to farther and farther objects, it seems as if we are penetrating ever more into the very realm of the gods.

Such questions as How large exactly is the Universe? Did it have a beginning? and if yes, Why? and How? are asked by people who look up at the stars and want to know what is behind them. Since the invention of the telescope in the early years of the 17th century, we think we have made good progress towards answering the first of these questions. We can study the Universe as it is today and develop reasonable ideas about its size and structure. It is more difficult to answer questions about past events (most likely a very remote past which no human being has witnessed), for such information can only be obtained through indirect methods.

This remoteness in space and in time, however, has not stopped man's investigation. From time immemorial there have been speculations, eventually followed by observations and calculations about the possible age of the Universe and the way it came into existence.

All measurement of time is based on the rate of changes. Ancient man saw the changing phases of the Moon; the Greeks observed the changing level of the water in their clepsydrae (water clocks); others noted the rising and setting of the Sun, or even much slower processes such as the growing of plants. From this last example it already becomes clear that slow changes are more difficult to measure than rapid ones, and that one must measure very carefully in order to cover the long time span over which the Universe has apparently existed.

Early ideas about this measurement of change are aptly expressed in the Bible, where scoffers are credited with saying that "Since the fathers fell asleep, all things continue as they were from the beginning of the creation" (2 Peter 3:4). Of course, this opinion also shows how difficult it is to measure slow changes. Little progress in determining the age of both the universe and this world was made in the centuries following the above statement. A breakthrough came in the middle of the 18th century when Georges-Louis Leclerc, Comte de Buffon, used the idea that the Earth was originally molten and cooled to its present condition. In this way he estimated the age of the Earth to be a record-breaking 74,832 years!

Soon further steps were taken. In 1785 James Hutton formulated the main dictum of uniformitarianism: "The past history of our globe must be explained by what is seen to be happening today"; and in 1859 Charles Darwin published *The Origin of Species*. At first the ideas about long geological periods and slow biological evolution could not be supported by actual measurements of long periods of time, but this changed around the turn of the century. In 1896 Henri Becquerel discovered radioactivity, and 13 years later Lord Rutherford developed the technique of radio-dating. Chemical elements were seen to have a finite existence. Knowledge about the rate of their decay allowed a determination of their age. This impermanence raised questions among those who had always believed in the intransient character of the chemical elements, especially since the old claims of alchemy had been laid to rest.

A deeper question resulted from these developments. Because many chemical elements come to an end, do they also have a beginning? If so, when and where? The answer came from unexpected quarters. In the first half of the 20th century, astronomers discovered that the energy which stars radiate comes from nuclear processes deep in their interiors, and that these nuclear processes are able to build complex atoms from relatively simple ones. By the middle of the century this insight led to the astonishing idea that all chemical elements more massive than beryllium are formed inside stars.

2) THE STANDARD MODEL FOR THE ORIGIN AND DEVELOPMENT OF THE UNIVERSE

This insight did not answer all questions. Soon people were asking the old questions with renewed confidence that answers might be forthcoming: Where do stars come from? Did the Universe have a beginning? and if "yes," When? and How? One of the greatest developments in astronomy occurred in the second half of this century with the formulation of various cosmological theories that offered answers to all these questions. The theory that has attracted most supporters is the so-called "Hot Big Bang" model, a summary of which is found in Table 1.

TABLE 1. The Hot Big Bang (or Standard) Model

A Short Description

- The Universe is 10-20 thousand million years old;
- It started with rapid expansion (inflation) of super hot and dense "primordial matter" consisting of subatomic particles, such as quarks and anti-quarks;
- The subsequent phase of expansion caused a gradual cooling;
- As the temperature dropped, other particles were formed: electrons and positrons, protons and anti-protons, neutrons, and finally nuclei of hydrogen, deuterium, helium, lithium and beryllium (the primordial elements);
- During the first 300,000 years or so, matter and radiation were coupled (in thermal equilibrium);
- When the temperature reached the vicinity of 3000 K, the Universe became transparent, i.e., matter and radiation "decoupled";
- Finally, galaxies and stars were formed.

[Note: Peebles at al. (1991) and Peebles & Silk (1990) give more information on the Standard Model and its merits, respectively; an alternative view is presented by Arp et al. (1990), and an evaluation of various theories for the origin of the Universe's large-scale structure is given by Kashlinsky & Jones (1991).]

This model is also called the Standard Model mainly because it is more consistently supported by astronomical observations than any other. Among these observations, three are considered especially important:

a) almost all galaxies show a so-called redshift;

b) the existence of a general radiation with a temperature of about 3 K, the so-called microwave background radiation (MBR) (here, K stands for Kelvin, the absolute temperature scale on which 273 K = 0ºC); and

c) the observed cosmic abundances of hydrogen, helium, lithium and beryllium.

The redshifts had been found at a time when cosmological ideas had not yet been developed to a very great extent and before the Standard Model was conceived. Probably because of this, there is a larger element of philosophy in the interpretation of red shifts than of any other observations.

During the 1980s the Standard Model lost some of its popularity, primarily because certain observations were casting doubt on two of its main pillars — the redshifts and the MBR. In the case of the redshift determinations, the disturbing elements are the apparently discordant redshifts of many galaxies and quasars as exposed, e.g., by Arp (1987 and references therein), and the possibilities for non-cosmological redshifts summarized, e.g., by Narlikar (1989). Redshift observations and some of the problems involved in their interpretation will be discussed in Section 4.

In the case of the MBR, after its discovery and early agreement with theoretical predictions, its acceptance declined as solid support for the Standard Model, because increasingly accurate measurements failed to detect the inhomogeneities that the Universe's large-scale structure suggested should be present (e.g., Schwarzschild 1990). However, hopes that all would be well with the Standard Model were boosted by the recent announcement of inhomogeneities in the MBR (this will be discussed in Section 7).

3) REDSHIFTS AND THEIR INTERPRETATION

The principle behind the redshifts is very simple. Any wave emitted by a source which is moving with respect to the observer will have a changed frequency when observed. This is called the Doppler effect. For relative motion which increases the distance between source and observer, the light received will have a longer wavelength, i.e., it will be more red than at the source. Conversely, the light from an approaching source will be more blue.

The question of whether galaxies were objects in our Milky Way or were other "milky ways" (galaxies) at large distances was the subject of a celebrated debate in 1921. The conclusions to be drawn from that debate were unclear, but the matter was settled in 1924 when Edwin Hubble studied Cepheid variable stars in other galaxies and proved unambiguously that the majority of observed "nebulae" (as all nebulous objects including the external galaxies had been called until that day) were indeed at great distances outside our Galaxy.

Hubble and others then proceeded to observe many galaxies and found that almost without exception they showed red-shifted spectral lines which seemed to resemble Doppler shifts, i.e., they seemed to be the result of receding movement. There are at least two serious objections against the way in which this interpretation was derived: 1) it includes a number of philosophical assumptions which should not be present in a purely scientific process; and 2) while it assumes that the observed redshift is caused by the Doppler effect, one should not forget that there are other ways in which redshifts can be produced.

By the end of the 1920s, when Hubble had enough observations to begin formulating possible interpretations, he was already convinced of the large distances of the galaxies. What he saw amounted to increasing redshifts for galaxies at increasing distances from the Sun. Hubble, however, was careful not to call them Doppler shifts. He called them "apparent velocity-displacements," thus leaving open the way they should be reinterpreted.

Nevertheless, Hubble could not escape the challenge of interpreting his observations. To do this he needed a model of the Universe into which his observations could be fitted. There were three different cosmological models in those days, formulated by Georges Lemaître, Edward Milne, and Fritz Zwicky. Both Lemaître's and Milne's models were recessional, i.e., they included an expanding universe, in one form or other. Zwicky's model was non-recessional.

To distinguish between the recessional and non-recessional model, it is necessary to measure nebulae at very large distances where the difference between recession and no recession becomes increasingly apparent. Unfortunately, the faintness of the nebular images produced by the instruments of those days did not allow a reliable measurement of sufficiently distant nebulae.

In their analysis, Hubble and Tolman (1935) introduced a brightness correction Δm which allows comparison of nebulae at different distances. The correction increases with distance and is larger in a recessional model. Spatial curvature also affects the value of Δm, but only in recessional models. To fit their observations to the two models, Hubble and Tolman had to introduce a rather strong spatial curvature into the recessional model, and they concluded:

> *... it might be possible to explain the results on the basis of either a static homogeneous model with some unknown cause for the red-shift or an expanding homogeneous model with the introduction of effects from spatial curvature which seem unexpectedly large but may not be impossible.*

However, they also state that the necessity to introduce spatial curvature

> *... must be regarded as in conflict with our usual notions as to the distances to which observations would have to be*

> *carried before appreciable effects from spatial curvature would seem probable.*

In other words, curvature effects are only noticeable at distances much larger than those of the farthest galaxies that had been observed until then.

Thus, the observational evidence pointed towards non-recessional models of the Universe. However, in subsequent papers, Hubble showed a clear inclination towards recessional models, and he finally concluded that the Universe must be expanding.

According to Hetherington (1971), Hubble arrived at this conclusion primarily because of deep philosophical reasons, for he assumed two very fundamental principles: General Relativity and the Cosmological Principle (discussed below). Because Zwicky's theory did not fit the prediction of an unstable universe made by the theory of General Relativity, and because it introduced so-called new physics to explain new observations, Hubble rejected it despite the indications to the contrary from his own observations. Thus, the cornerstone of one of the most interesting and important theories concerning the origin of everything was laid on a philosophical foundation. This often-forgotten fact is appropriate to recall here because scientists often accuse creationists of committing this kind of "mortal sin" in other areas.

The fact that the Standard Model has a philosophical foundation does not imply that it is necessarily flawed. However, in a society that aims at understanding the Universe in purely physical terms, the Standard Model should at least be viewed with a good dose of suspicion. In principle, other mechanisms can produce redshifts, and they have been evaluated by Narlikar (1989). Although some of these do not seem to harbor much promise, various possibilities remain open, encouraging the seeker for truth about the origin and structure of the Universe not to hesitate to investigate alternatives to the Standard Model.

4) THE COSMOLOGICAL PRINCIPLE

In speaking of the Universe we are really referring only to the Visible Universe. The actual Universe may be infinitely larger but, by definition, we cannot know anything of what happens beyond our cosmological horizon. The Cosmological Principle has been invoked to extend our knowledge of the Visible Universe to the Universe as a whole. In its simplest form it states that the Universe looks the same from every location within it.

At first it may seem that the increasingly large redshift of the more distant galaxies would lead to the inescapable conclusion that the Earth is the center of an expanding Universe, and therefore contradictory to the Cosmological Principle. However, this is not really a problem. An expanding universe in which the rate of expansion increases linearly with distance does look the same from every location within it. However, the Cosmological Principle is a purely philosophical assumption which is unfalsifiable because we are unable to move to a sufficiently different location in space to check its validity.

In fact, at whatever scale one looks, the Cosmological Principle does not seem to hold. The Solar System looks very different from different locations within it, and the Milky Way with its flattened disk and spiral arms does not look the same from every viewpoint. Looking at the galaxies in the Local Group, in the Local Supercluster, or at even larger distances, one sees very inhomogeneous distributions of matter. One can maintain that all this unevenness will smooth out if one were to look at larger scales. With our sophisticated astronomical instruments, we seem to be able to see almost as far as we possibly can (e.g., for a very large redshift of $z = 4$, we can see galaxies at a time when the Universe was only 20% of its present size). This means that we can investigate the Universe over a substantial fraction of the entire diameter of what could possibly be seen. The fact that we have seen structures on ever larger scales and not much of the smoothness postulated by the Cosmological Principle (Schwarzschild 1990), does not augur well for the ultimate triumph of the Cosmological Principle when extended to the whole Universe. Furthermore, if the Cosmological Principle does not hold, the Standard Model on which it is based is also in trouble. This is a second reason to consider alternatives to the Standard Model: the Cosmological Principle is not a very sound foundation on which to build, despite its philosophical attraction in some quarters.

Let us consider a biblical view of the Cosmological Principle, especially with respect to the Earth which has a special place in God's Word. Is Earth's special place contradictory to the Cosmological Principle? Probably not; Earth's unique role is related to its moral condition. Considered as a planet in the physical sense, Earth may not be unique, despite the definite impression we get that many of the heavenly bodies were created especially for the benefit of the Earth and its people (see Genesis 1:14-17, "lights" and "signs"). Astronomers have various arguments in favor of an abundance of planets throughout the galaxies (see, e.g., Huang 1959), and even the Bible seems to imply that there are many other worlds — inhabited planets — in the Universe.* The problem for those who practice physical cosmology is twofold: 1) the apparently logical assumption of the Cosmological Principle is deeply philosophical, and 2) it may not even be true.

5) THE AGE OF THE UNIVERSE

Before discarding the Standard Model, we must consider another of its aspects. The possibility that the Universe is actually expanding is of interest to the creationist, as well as to others. If the Universe is expanding today, it must have been smaller in times past. Going back far enough in time, one arrives at an epoch when all things in the Universe were at their closest just before they were driven apart by the Big Bang. This would point to a definite beginning of time in the Universe, an idea very much in harmony with the way the Genesis record is often interpreted.

There are also troublesome aspects to the Big Bang hypothesis. For creationists the biggest problem is the long time that allegedly has elapsed since the explosion that set everything into motion. It is not immediately obvious that there is any possibility of reconciling the postulated 15 or so thousand million years since the Big Bang with 6000 or so years since the events reported in Genesis 1. The problem has some similarity to the time problem in geology. Radio-dating methods have given ages of millions or billions of years for many rocks; ages which, despite their being subject to the problems inherent in our lack of knowledge concerning initial clock settings, seem reliable but which cannot be reconciled with a 6000-year time scale and have forced consideration of an old age for planet Earth. I think that the Genesis record does not contradict such a conclusion (Roth 1992), and that despite problems concerning the initial setting of the radiometric clocks, it is quite acceptable to believe that many of the old radio-dating ages for terrestrial rocks indicate an ancient Earth.

An age of 15 thousand million years for the Universe would not disagree with the geological age of planet Earth, which is only a factor three smaller. However, there are other ways in astrophysics of estimating

*Texts such as Nehemiah 9:6, Job 1:6-7, Luke 3:38, and Ephesians 3:15 can be understood as pointing to "sons of God" who could, like Adam, have been the fathers of races on other worlds, but who all belong to the Universe-wide family of God.

age which give more doubtful conclusions, because conditions similar to initial clock settings are unknown. One is the assumption that in the initial stage of the Universe there were not only hydrogen, helium, lithium and beryllium as the Standard Model indicates, but that there were also heavier elements. Such an initial enrichment is not possible under Big Bang Model assumptions which limit the quantities of heavier elements produced in the very early stages to negligibly small amounts, and delay significant production to later inside stars (Wagoner, Fowler & Hoyle 1967). Astrophysical observations indicate quite unequivocally that, within the context of the Standard Model, there have been no primordial elements other than H, D, ^{3}He, ^{4}He, and ^{7}Li (Pagel 1991).

This does not necessarily prove that only these five primordial elements were produced in the hot Big Bang of the Standard Model. There are several mechanisms of baryosynthesis (Schramm 1991), even at temperatures as low as 10^{15} K (Linde 1991). (Compare this with the temperature of 10^{32} K supposed to have existed at the time of the Big Bang.) If any of these other mechanisms has been operative on a large scale, the abundance of the heavier elements at the time the first stars were formed could have been much higher than the Standard Model predicts, and problems similar to the clock setting in radio-dating methods arise. If this were the case, many age calculations done by the theory of stellar evolution would be invalid.

In conclusion, we find that both geology and cosmology use dating methods capable of giving reliable results (which are not contradictory to the Bible record even when they give extensive ages for certain objects), while there are other methods whose results must either be received with much caution or rejected altogether. Unfortunately, because we are dealing with events from the remote past, it is not always easy to decide which methods are the more reliable. Even when there are good arguments favoring an “old” Universe, its precise age remains difficult to determine, and there is room for considering alternative cosmologies.

6) THE ECHO OF THE BIG BANG

In the Big Bang scenario, the Universe started with an extremely high temperature and cooled as it expanded. After about 300,000 years, when the temperature had decreased to 3000 K, matter and radiation became decoupled, i.e., the density and temperature of the Universe had become so low that the two were no longer connected on an equilibrium basis. Thereafter the Universe has expanded a thousandfold in every direction; stars, galaxies, planets and man have come into being; and the background temperature of the Universe has dropped to a mere 3 K.

This radiation is called the “echo of the Big Bang.” Arno Penzias and Robert Wilson were awarded the Nobel Prize for its discovery in 1964. Also called the 3 K microwave background radiation (MBR), its detection was one of the main reasons why most scientists accepted the Standard Model as the true description of the Universe. However, in order for stars and galaxies to form subsequently, small density inhomogeneities from which later stars and galaxies could grow must already have existed at the moment of decoupling of matter and radiation. The corresponding fluctuations (anisotropy) in the MBR have been predicted by theory to be about one part in 10^5 over angular scales of 1º to 90º.

Until recently, all observations have found the MBR to be extremely isotropic, even from widely differing directions. For two reasons, this had always been considered a serious set-back for the Standard Model. First, regions of space so far apart that there could not have been a causal connection since the moment of the Big Bang still show the same temperature. This problem was solved by postulating a so-called “inflationary” phase during the very first moments after the Big Bang. This initial phase of comparatively rapid expansion led to a highly homogeneous, isotropic Universe, free from such complications as magnetic monopoles, primordial black holes and others (Guth 1981). Second, the presence of MBR isotropy cannot be reconciled with the existence of large-scale structure in the Universe, which can only be understood if there were density fluctuations in the early stages. These fluctuations would be seen today as in-homogeneities in the distribution of the MBR over the sky. The expected MBR in homogeneities were small and had not been detected despite a large number of thorough searches (Schwarzschild 1990).

For the survival of the Standard Model, a solution to this MBR problem was vital. A special satellite named COBE (Cosmic Background Explorer) was launched in 1990. COBE’s first measurements showed the customary perfect black-body distribution of radiation with a temperature of 2.735 K, with deviations less than one quarter of 1%. More recently, however, with the accumulation of more data, it has become clear that the MBR is not completely uniform. The April 1992 announcement of the discovery of fluctuations in the MBR caused a flurry of publicity. There are temperature fluctuations with an amplitude of 1.6×10^{-5} K, very close to the theoretical prediction (Goss Levi 1992). From this point of view the COBE measurements agree with the present-day large-scale structure of the Universe as predicted by the inflationary Standard Model. The recent measurements do not, however, point unequivocally to one particular cosmology (nor even to one particular group of cosmologies) as the only valid description of the Universe's origin and structure (Flam 1992).

There are still problems to be solved. On smaller scales, for instance, the Standard Model predicts too much gravitational influence (Silk 1992). Be this as it may, the detection of the MBR fluctuations is a remarkable achievement. The still-existing discrepancies between prediction and observation require a deeper understanding of the way galaxies and clusters are formed. The search for mechanisms and viable alternative hypotheses must continue before a final verdict can be given.

Many newspapers and other media reports asked the question: With this fresh confirmation of the Standard Model, does God still fit into the picture, and how? The COBE team leader George Smoot was quoted as saying, "If you're religious, it's like seeing God." It should be understood that these measurements are at the limit of detectability and need independent confirmation before they will be widely accepted. Furthermore, COBE was not designed to answer any religious questions. Nevertheless, these measurements provide another step in scientists' attempts to construct a "theory of everything." However, in its attempts to find explanations for everything, physical science finds itself limited to the physical world, and it will sooner or later have to admit that there are other than physical realities to the Universe. God is such a reality and, therefore, is not subject to physical investigation (though some of His actions may be), and neither is His existence in question here. Rather, the limitations of science will contribute to a confirmation of the claims made in His Word.

7) FINE-TUNING OF THE UNIVERSE

Another interesting characteristic of our Universe of which we have become aware from the claims of the Standard Model (and one which creationists have often been quick to point out and try to use to their advantage) is the fine tuning of physical parameters. Consider the initial force of the Big Bang. If this force were too large, the Universe would expand quickly to a state of low density in which there would be insufficient material to form stars and galaxies. On the other hand, if the force of the initial explosion were too small, gravitational attraction would have slowed down the expansion long ago, and the Universe today would either be contracting or have collapsed. Neither possibility corresponds to the real Universe as we know it. This means that the force of the Big Bang had to be finely tuned.

In order to appreciate how finely tuned, we must realize that the final fate of the Universe as far as its expansion is concerned depends entirely on the density of the matter within it. The critical density which divides the two possibilities of eternal expansion and future contraction is about 5×10^{-30} g cm^{-3}, which corresponds to about 3 hydrogen atoms/m^3. A determination of the actual density of the Universe would allow a good guess about its future. Such an estimate is not easily made, and values given by different scientists obtained with different methods vary. Nevertheless, all such estimates show that the present density of the Universe is quite close to the critical value. This is a remarkable coincidence that has been difficult to explain. This so-called "flatness" problem is remarkable because a "flat" Universe today means its density must have been finely timed in its early phases (i.e., the tuning at a very early epoch must have been accurate to 1 part in 10^{49}). This is not fine tuning; this is *extremely* fine timing! If the original density had been slightly higher, the Universe would already have collapsed. Had it been slightly lower, today's density would not have been enough for stars and galaxies — and, as evolutionary proponents of the Standard Model say, for man — to form.

This near equality of the actual and the critical densities has inspired many cosmologists to believe that these two values are indeed identical, and that the Universe will continue to expand forever. One can easily understand how such an opinion comes to be expressed. The fact that we are here becomes a less probable situation only if the Universe has had sufficient time to develop us, i.e., if it is flat.

Although the assumption of a flat Universe has a strong philosophical bias, it has been possible to construct a theory which explains why this situation exists. The inflationary universe scenario introduced in 1981 by Guth (1981) and later modified by Linde (1983) solved the flatness problem by depicting a universe which is indistinguishable from a flat one, i.e., it predicts that the present density of the Universe is very close to its critical value. However, since inflation to the present status is possible only if a very special set of initial conditions is met, this scenario carries its own fine tuning (Narlikar 1988).

The above argument, and similar ones based on other instances of fine-tuning (see Section 9 and Gribbin & Rees 1990), can also be reversed. One could say that the Universe is as it is because we are here to observe it. This is one form of the so-called Anthropic Principle. For creationists this may seem to offer a fantastic opportunity to practice natural theology. One would first point out the near impossibility of this fine tuning and then proceed to argue that it could have been achieved only if there was a higher power responsible for it.

Those who would use this argument to favor creationism should consider that it is impossible to prove the existence of God through scientific arguments. As Barrow (1990, p 365) has stated, such arguments have to start with certain assumptions and then proceed by deduction to infer the existence of God. Such a process does not lead to firm inescapable conclusions, but rather to choices about believing or not believing the starting assumptions. The Anthropic Principle identifies certain necessary conditions for the existence of life, but these conditions do not guarantee that life will exist. Also, the fine balancing seemingly implied in the Standard Model could disappear if the Big Bang never happened, or if we arrive at a more complete understanding of its mechanism which explains how the coincidences occurred. Finally, we must grant science time to find its own tuning mechanism. While at this moment a direct action by the Creator may be invoked for an "explanation," one cannot be sure that this is the scientifically safe, long-term position. The absence of a tuning mechanism today cannot be construed to be evidence that such a mechanism does not exist. However, as Barrow (1990) concludes, while the Anthropic Principle cannot be used as a proof of God's existence, it certainly does not contradict such a conclusion.

8) MATTER/ANTIMATTER ASYMMETRY

Yet another example of fine timing is the relation between matter and antimatter in the early Universe. For almost every type of matter particle there is an antiparticle. Positrons are the antiparticles of electrons, protons go with antiprotons, etc. Bringing together a particle with its corresponding antiparticle results in the complete annihilation of the two particles, and the simultaneous production of electromagnetic radiation. Theoretically, matter and antimatter would have come into existence in equal amounts at the time of the Big Bang. Such a perfect symmetry would have resulted in the complete annihilation of both, and the Universe today would have consisted of radiation only. This is clearly not the case; the Earth below our feet is real matter!

Somehow, the Big Bang produced more matter than antimatter. After all antimatter was annihilated by matter, the particles which make up today's Universe remained. The energy content of the Universe today is the remnant of this annihilation radiation. Since matter carries only one part in 10^9 of the Universe's energy and the rest is in radiation, this means that for every 10^9 antiparticles, 10^9 and one particles were formed. According to the Big Bang theory, this is why matter, including ourselves, exists.

Recently, some progress has been made towards explaining this asymmetry. It depends on two different mechanisms: a) a process of converting matter into antimatter and vice-versa, also known as baryon-number-conservation violation; and b) some asymmetry between matter and antimatter that would make the above process favor the direction towards matter, also known as charge-parity symmetry violation. The first process could possibly be found in an amplified version of the 't Hooft effect ('t Hooft 1976a,b; Shaposhnikov 1991). The second requirement has been harder to meet. Recent speculative extrapolations (McLerran et al. 1991), while offering some promise of success, need the Super-conducting Super Collider to confirm that speculations are on the right track (Freedman 1991).

Even if such experimental support should be forthcoming, there will still be a problem in validating the proposed mechanisms, because they are effective only at energies well beyond what our highest hopes for particle accelerators can reasonably expect. Also, they were operative in an era far earlier than the production of the light that can be detected by any telescope.

We see, again, that in order to explain certain aspects of the Universe, science must have recourse to unverifiable theories. In matter/antimatter considerations there is additional evidence that science leaves plenty of room for believing in the miraculous (i.e., not according to known natural laws) intervention of God in the origin of the Universe.

9) HOW THE UNIVERSE BEGAN

While there seems to have been some success in answering the question about when the Universe began, science has found it much more difficult to answer the question about *how* it began. Several recent ideas about its beginning have been proposed. Rather than crediting

God with an act of creation, physicists have conceived "natural" processes which might produce a universe like ours. We are almost capable of reproducing the conditions necessary for one such process (quantum mechanics) to occur in the laboratory, using a total mass of only about 10 kg (Guth 1991 and references therein).

Another proposal lies in so-called quantum fluctuations in which particles emerge spontaneously and temporarily from a vacuum (Tryon 1983). There is an uncertainty relation for the particles' net energy, E, and their lifetime, t, with $\Delta E \times \Delta t \sim h$. A vacuum fluctuation on the scale of the Universe may be possible because theory does not limit the scale as long as this uncertainty relation is fulfilled. Accordingly, such a Universe can exist sufficiently long, $\geq 15 \times 10^9$ years, if the energy is sufficiently small. This is believed possible in a closed universe in which physical quantities are conserved, and particles and their antiparticles are generated in equal amounts, so that the total net energy of the Universe, the sum of mass energy and potential energy, is zero or almost zero.

This is one example of how modern theoretical physics attempts to find answers to the question of what the Universe really is, and how it was formed. One might ask whether the veil on creation has now been lifted and science has found the secret. Before an affirmative answer is given, it should be remembered that we are dealing with phenomena at the very edge of (and beyond) our knowledge of physical theory, and that, therefore, the uncertainties about the validity of the assumptions are at least as large as in the case of creation of all matter by God in an even more miraculous way, i.e., outside the known laws of physics. Even if some of the proposed mechanisms are capable of some degree of verification through their predictions about present conditions, it will most likely still be impossible to give definitive, unambiguous answers to the question about how the Universe began.

Premonitions about this impossibility are probably among the main reasons why some scientists have tried to avoid giving any answer to the above question. Instead, they have postulated that the expansion of the Universe will ultimately cease and that thereafter there will be collapse. After it has collapsed to sufficiently high temperatures and pressures, conditions would be ideal for a new explosion or a bounce. This process might have been repeated many times. Such an "oscillating universe" could have existed from much earlier times, and continue to exist for a much longer time than a universe which continues to expand forever.

While experience suggests that entropy can only increase and that with each succeeding generation an oscillating universe would slowly degrade, it is also conceivable that in the new physics entropy is largely or completely eliminated after a bounce. If in addition some fresh matter could be created in such a universe with every bounce (possibly through vacuum fluctuations), the universe would continually grow and contain enough particles to support life. Further, because of the increased energy content in every new cycle, each cycle would last longer than the previous one (Dicke & Peebles 1979).

Whatever the length of time a hypothetical universe can exist, the oscillating universe is an unsatisfactory answer to the question about origin. It is not (yet?) scientific because it postulates unverifiable conditions. And for the creationist it is no answer at all. While God's creation could have existed over a vast length of time, to have it go through a series of creation-like events and subsequent apocalyptic destructions seems contrary to all we seem to know about the Creator, despite the "precedent" of the worldwide Noachian flood. There is no need for a long history of the Universe, or the presence of a sufficiently high number of particles in order to facilitate the process of biological evolution, if one believes in the origin of all living things according to the Genesis account.

10) THE SINGULARITY

There are other philosophical reasons for considering alternatives to the Standard Model. Consider the physical conditions in the Universe at the time of the Big Bang. At that time many physical quantities had unrealistic values that modern physics has not yet been able to deal with and probably never will. In mathematics (the language in which scientists describe their models) this is called a singularity. Because physics cannot really deal with singularities, it looks as if there was something similar to ex. nihilo creation "in the beginning." If everything must have a cause, this is an argument for the existence of God as the One providing not only a physical cause but also deep philosophical and/or religious meaning.

On the other hand, if God Himself had no cause because He exists from eternity, one might ask why the Universe should have a cause. Why could it not have existed from eternity? In a world view which accepts the existence of an eternal God, this is equivalent to making the Universe sufficiently equal with God to produce a direct conflict with the Bible's presentation of God as the unique Creator.

Finally, it is also possible that the singularity does not exist at all in the real Universe but was introduced because of the shortcomings of our physical knowledge and mathematical tools. While it is an accepted and acceptable practice to describe nature by models that we know are only approximations to reality — often very close approximations indeed! — to reason about the origin of the Universe and the need for God from such approximate models seems to betray a deep reluctance to admit His existence and influence in the affairs of man, even a deliberate attempt to expel Him from His own world.

It is interesting to reflect for a moment on the implications of a possible singularity or a beginning of the Universe, by considering the following three necessary but insufficient conditions for the existence of such a singularity (Penrose & Hawking, as quoted in Barrow 1990, p 228):

a. Gravity must attract everything. This is a problem for the Standard Model because inflation requires just the opposite.
b. Time travel must be impossible. The Theory of Relativity, which forms one of the cornerstones of the expanding-universe model, allows time travel. In places where space is very strongly curved, it is theoretically possible to take a short-cut and reach a location in space-time which lies actually in the past. This, of course, causes a dilemma if the time traveler should find himself a contemporary of his grandmother and killed her before his mother (or father) was born. However, if the time loops are sufficiently large (i.e., if they carry us to a sufficiently distant past), the "what if I killed my granny?" contradiction could not yet have arisen.
c. The Universe is expanding and contains a sufficient quantity of matter for its ultimate collapse. It appears unlikely that this condition is fulfilled. There does not seem to be enough matter in the Universe for assurance that expansion will not continue forever.

These conditions cannot be fulfilled in the Standard Model. This does not mean that there has not been a singularity. The Universe could have had a beginning in time under different conditions. Whatever the difficulties, the search for physical processes must continue. It is to be expected that this search will, at best, lead to an indication of which processes were involved in the formation of the Universe, without being able to provide us with real causes. I consider it highly probable that a set of alternative conditions could be provided by the action of God as Creator.

Thus, either the Universe had a beginning in space and in time, in a singularity or otherwise, or it existed from eternity. In either case it would be impossible to speak of "before." Here it is appropriate to recall the words spoken by Judge William Overton at the 1981/82 Arkansas Creation Trial:

> *'Creation out of nothing' is a concept unique to Western religions. In traditional Western religious thought, the concept of a creator of the world 'out of nothing' is the ultimate religious statement because God is the only actor.... The only one who has this power is God.... The idea of sudden creation from nothing, or creatio ex nihilo, is an inherently religious concept.*

It seems that scientific cosmologists are approaching religious thinking when they speak about virtual quantum fluctuations, charge-parity symmetry violation, and even singularities, as a way of starting the Universe! So why not admit that God is the Creator? After that we can use the Bible to find out why He created, and science to reveal some of His methods.

11) THE HUMAN FACTOR

Another philosophical reason for considering alternatives to the Standard Model lies in the so-called "human factor." Whereas only the very lightest chemical elements were produced in the first few minutes of the Big Bang, men and animals contain a large proportion of heavier elements. According to the Standard Model, these were generated in the nuclear ovens deep inside stars. Toward the final phases of a star's existence as a luminous body, when its central temperature is increasing to ever higher values, the processes of nucleogenesis generate the heavier elements. After the star's final breakup, these are delivered to interstellar space, ready for incorporation into the next generation of stars and planets. Somehow, somewhere, the conditions for the synthesis of complex molecules, such as amino acids, and other essential elements of life, would have been fulfilled to begin the long journey of evolution leading ultimately to man.

While this scenario has claimed to offer some harmony with the biblical statement about our formation from the "dust of the ground," it does not explain how we came to possess the “image of God,” and it reduces the Genesis account to mere mythology.

The Standard Model sees man as a unique product of physical, chemical, biological and other physical processes. In addition to explaining why the Universe and we are here, such human characteristics as love, hate, beauty, sorrow, happiness, etc., need to be addressed. The Standard Model offers only some explanation of how we came to be here — through the extremely improbable and therefore rather accidental synthesis of a number of amino acids. Those who want an answer to the deeper question of why we are here would be much better advised to consult the Word of God than the latest embellishments of the Big Bang theory. It is fair to say that here is a prime example of how the neglect of non-science by scientists has impoverished cosmology, resulting in a lack of direction, and much senselessness and fatalism.

The emptiness of today’s model of the beginning of the Universe has been described clearly by Steven Weinberg (1978), who was awarded the 1979 Nobel Prize in physics:

> *It is almost irresistible for humans to believe that we have some special relation to the universe, that human life is not just a more-or-less farcical outcome of a chain of accidents reaching back to the first three minutes [of the universe], but that we were somehow built in from the beginning.... It is very hard to realize that this all is just a tiny part of an overwhelmingly hostile universe. It is even harder to realize that this present universe has evolved from an unspeakably unfamiliar early condition, and faces a future extinction of endless cold or intolerable heat. The more the universe seems comprehensible, the more it also seems pointless.*
>
> *But if there is no solace in the fruits of our research, there is at least some consolation in the research itself.... The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy* (p 154-155).

Another reason for considering alternatives to the Standard Model lies in the fact that its adherents reject various possible alternatives because they might be philosophically unattractive or unsatisfactory. Hubble’s conclusion about the redshifts and the expanding Universe is an example. Scientists *do* have their own philosophical presuppositions. One would be their belief that everything must be explained through natural laws, maybe even typically non-physical phenomena such as love, hate, beauty, and life. In this process there is no longer a need to include God. As Dyson once said, cosmology has deteriorated to the level of "cosmolatry."

12) THE DIVINE ALTERNATIVE

NASA astronomer Robert Jastrow (1978), after discussing the as-yet-inconclusive results of our investigations into the origin of the Universe, writes:

> *Now we would like to pursue that inquiry farther back in time, but the barrier to further progress seems insurmountable. It is not a matter of another year, another decade of work, another measurement, or another theory; at this moment it seems as though science will never be able to raise the curtain on the mystery of creation. For the scientist who has lived by his faith in the power of reason, the story ends like a bad dream. He has scaled the mountains of ignorance; he is about to conquer the highest peak; as he pulls himself over the final rock, he is greeted by a band of theologians who have been sitting there for centuries* (p 115-116).

I would like to think that the theologians of the above quotation have been enjoying the panorama their high position affords. Their presence reminds us of the possibility for considering alternative scenarios that go beyond the purely physical into the metaphysical and/or religious fields. We are even more justified in doing so because our discussion of the Standard Model has revealed numerous reasons why the search for alternatives must continue. There are the instances of fine-tuning which become all the more remarkable once one admits that the *a posteriori* explanation given through the Anthropic Principle may be an act of evading the real issue: To what extent must God be brought into the scenario to make it viable?

The role God would have played in the origin of the Universe varies with different people. Some say that because they don't know about the very beginning of things, nor about what went before or how life itself originated, we should believe in a God. This is the position of deistic evolution, which I consider a negative view. As soon as science finds an explanation for what is still a puzzle today, such a God is no longer required. This is one reason why even in many so-called Christian churches today, God has slowly but surely been pushed back further into the shadows.

A more positive view is to believe in creation by God as it is described in the Bible. People who believe in God on this basis never do so because of any shortcomings in scientific theories, but because they have a personal relationship with God which has taught them that His Word is thoroughly reliable. This view is also positive because it includes some understanding of good and evil, the purpose of life, and other non-physical questions which science cannot address. People with this view, realizing that there is more to the Universe than meets the eye, are open to some so-called unscientific alternatives which have already been rejected by the "pure" scientists. As Einstein once expressed it: "Science without religion is lame, religion without science is blind" (Frank 1947). God is not seen to be in competition with science as a means for explaining life and the Universe.

Finally, let us reflect on time before the singularity. In our physical theories there is no "before," i.e., the Universe must have originated spontaneously. The Bible tells us that before the "beginning" there was God. This has led some to ask what it was that God was doing before He created the Universe. The 5th-century sage St. Augustine of Hippo is said to have given this answer: "Before He created Heaven and Earth, God created hell to be used for people such as you who ask this kind of question" (Oliver 1988).

CONCLUSIONS

We can now give an answer to the questions posed at the beginning of this article. The current scientific picture of the origin and structure of the Universe — the Standard Hot Big Bang Model — is not altogether in conflict with the Genesis account. Those who acknowledge the lack of scientific definition in Genesis will find much room to accommodate many aspects of the Standard Model. Its great age of 15 billion years could be loosely correct if one limits this age to the inanimate, physical Universe. Those who are prepared to accept an extensive age for the physical Universe should acknowledge the considerable uncertainty regarding the exact value.

The Standard Model has weaknesses. First, the interpretation of the observed redshifts as due to a general expansion of the Universe is based on philosophical arguments, and goes beyond the normal confines of physical science. Second, another cornerstone of the Standard Model, the Cosmological Principle, is a purely philosophical assumption which may be incorrect. Third, while the recent discovery of anisotropy in the MBR seems to provide solid support for the Standard Model (by being consistent with the formation of the present-day large-scale structure), some speculative physics is required over the very early inflationary phase to avoid producing a Universe without such anisotropies.

While the above are somewhat negative arguments for considering alternatives to the Standard Model, there are a number of remarkable coincidences in the Universe which point to an intelligent design. Among these we count the flatness (see Section 7) of the Universe. The fine tuning this requires has been accounted for in an early inflationary phase. However, the inflationary model needs some finely tuned physical conditions for its own success. This problem is not solved by the adoption of the Anthropic Principle (see Section 7). This is another instance of the introduction of deeply philosophical arguments into what is meant to be a purely physical theory.

Another coincidence is found in the small asymmetry between matter and antimatter. While science does not lack theories to explain this, these explanations are based on almost unverifiable assumptions, because the presumed physical conditions at the beginning of the Universe are so remote from what we will be able to simulate in our laboratories for many years to come. These limitations prevent us from penetrating the earliest moments of the Universe and theorizing successfully about how it actually came into existence. The possible occurrence of a singularity at the beginning of the Universe leaves room for considering non-physical alternatives.

The Standard Model unquestionably conflicts with Genesis on the origin, characteristics, and purpose of life. The Standard Model provides presumably sufficient time for biological evolution to take its assumed course, while Genesis states quite categorically that all life is created by God. In fact, since creation by God seems to be an activity not limited to one week of intense activity, but a process which is repeated at various times and places throughout the Universe, alternative cosmologies such as the modified steady-state theory proposed by Arp et al. (1990) would seem to agree much better with the Genesis record — if they did not depend so much on Hutton's principle of uniformity.

In the end we come back to God as the only One who can answer our questions, because He is the Creator of everything and gave it beauty and purpose so that we might enjoy it, and enjoy seeking answers to all our questions.

REFERENCES

Arp H. 1987. Quasars, redshifts and controversies. Berkeley, CA: Interstellar Media.

Arp HC, Burbidge G, Hoyle F, Narlikar JV, Wickramasinghe NC. 1990. The extragalactic Universe: an alternative view. Nature 346:807-812.

Barrow JD. 1990. The world within the world. NY: Oxford University Press.

Brown RH. 1990. Correlation of C-14 age with the biblical time scale. Origins 17:56-65.

Dicke RH, Peebles PJE. 1979. The Big Bang cosmology — enigmas and nostrums. In: Hawking SW, Israel W, editors. General Relativity. Cambridge: Cambridge University Press, p 504-517.

Flam F. 1992. COBE sows cosmological confusion. Science 257:28-30.

Frank P. 1947. Einstein: his life and times. NY: Alfred A. Knopf.

Freedman DH. 1991. Concocting a cosmic recipe for matter. Science 254:382-383.

Goss Levi B. 1992. COBE measures anisotropy in cosmic microwave background radiation. Physics Today 45(6):17-20.

Gribbin J, Rees M. 1990. Cosmic coincidences. New Scientist 125(13 January):51-54.

Guth AH. 1981. The inflationary universe: a possible solution to the horizon and flatness problems. Physical Review D 32:347-356.

Guth AH. 1991. Can a man-made universe be created by quantum tunneling without an initial singularity? Physica Scripta T36:237-246.

Hetherington NS. 1971. Edwin Hubble and a relativistic, expanding model of the universe. Astronomical Society of the Pacific, Leaflet 509.

‘t Hooft G. 1976a. Symmetry breaking through Bell-Jackiw anomalies. Physical Review Letters 37:8-11.

‘t Hooft, G. 1976b. Computation of the quantum effects due to a four-dimensional pseudo-particle. Physical Review 14:3432-3450.

Huang S-S. 1959. The problem of life in the universe and the mode of star formation. Publications of the Astronomical Society of the Pacific 71:421-424.

Hubble E, Tolman RC. 1935. Two methods of investigating the nature of the nebular red-shifts. Astrophysical Journal 82:302-337.

Jastrow R. 1978. God and the astronomers. NY and London: W. W. Norton & Co.

Kashlinsky A, Jones BTJ. 1991. Large-scale structure in the Universe. Nature 349:753-760.

Linde AD. 1983. Chaotic inflation. Physics Letters B 129:177-181.

Linde A. 1991. Inflation and quantum cosmology. Physica Scripta T36:30-54.

McLerran L, Shaposhnikov ME, Turok N, Voloshin M. 1991. Why the baryon asymmetry of the universe is $\sim 10^{-10}$. Physics Letters B 256:451-456.

Narlikar JV. 1988. The primeval universe. NY: Oxford University Press.

Narlikar JV. 1989. Noncosmological redshifts. Space Science Reviews 50:523-614.

Oliver JM. 1988. Antes del Big Bang. Astrum (Magazine of the Agrupacion Astronomica de Sabadell, Spain) 81:3.

Pagel BEJ. 1991. Big-Bang nucleosynthesis — observational aspects. Physica Scripta T36:7-15.

Peebles PJE, Schramm DN, Turner EL, Kron RG. 1991. The case for the relativistic hot Big Bang cosmology. Nature 352:769-776.

Peebles PJE, Silk J. 1990. A cosmic book of phenomena. Nature 346:233-239.

Roth AA. 1992. “The fourth day: a discussion of some questions about the Genesis creation events.” Unpublished manuscript available through the Geoscience Research Institute.

Schramm DN. 1991. Big Bang nucleosynthesis: the standard model and alternatives. Physica Scripta T36:22-29.

Schwarzschild B. 1990. Gigantic structures challenge standard view of cosmic evolution. Physics Today 43(6):20-23.

Shaposhnikov ME. 1991. CP-violation and electroweak baryogenesis. Physica Scripta T36:183-193.

Silk J. 1992. Cosmology back to the beginning. Nature 356:741-742.

Tryon EP. 1973. Is the universe a vacuum fluctuation? Nature 246:396-397.

Wagoner RV, Fowler WA, Hoyle F. 1967. On the synthesis of elements at very high temperatures. Astrophysical Journal 148:3-49.

Weinberg S. 1978. The first three minutes: a modern view of the origin of the universe. Rev. ed. NY: Basic Books, Harper-Collins.