The Big Bang Model: An appraisal

by Mart de Groot

We need more than cosmology to understand the structure and the meaning of the universe.

Cosmology deals with the structure and origin of the universe. Modern cosmology started in the 1920s when the then-largest telescopes were being used to study the remotest objects in space and to find answers to questions about the structure of the universe. The answers led to questions about the origin of the universe. American astronomer Edwin Hubble's observations (1935) noted that almost all galaxies show a so-called "redshift." This means that the color of the light we receive from them is redder than when it left its source. One possible means of producing such a color change is through the Doppler effect, i.e., the movement of galaxies away from the earth.

To interpret his observations, Hubble needed a cosmological model of the universe. Several models were available at the time. Those by Milne and Lemaître allowed an expanding universe in agreement with Einstein's Theory of General Relativity. A model by Zwicky was more static but required fewer adjustments to known physics and no introduction of new concepts. It was, therefore, the framework into which Hubble's observations could most easily be fitted. Hubble himself was not too sure of how to interpret his observations and, being reluctant at first to draw the conclusion of an expanding universe, called the redshifts "apparent velocity displacements."

Shortly after, Hubble partly abandoned his earlier reservations and interpreted the redshift through the Doppler effect; i.e., he concluded that most galaxies are moving away from us. Thus the term "the expanding universe" came into being.

The expanding universe

The next step was a simple one. If today the universe is expanding, then, in the past it must have been smaller. Going back into the past far enough, the universe must have had some minimum size from which it expanded. It seemed a logical conclusion to say that the universe had a beginning in time. It should come as no surprise that this idea found favor with Christians who saw that moment in the past when everything started to expand as the equivalent of the "in the beginning" of Genesis 1:1. The question of how long ago this beginning occurred was not so easily answered. It was necessary to measure not only the present speed of expansion but also its variation with distance. The observed relation between distance and redshift is called the Hubble law, and the parameter that describes the expansion of the universe is the Hubble parameter, H_o. Hubble's first estimate gave H_o = 500 km/sec/kpc with a consequent age of the universe of 2 billion years.

The Big Bang

This caused an immediate problem, because geologists had already postulated the age of the Earth as some four billion years, and it was inconceivable that the Earth, as part of the universe, could be older than the universe itself. The reason for this low estimate for the age of the universe was the limited distance to which galaxies could be observed at that time. As more powerful telescopes came into operation, the value of H_o could be determined with greater accuracy, with a resultant better match between geological and cosmological time scales. By the 1960s, the situation had

improved so far that the then-widely accepted age for the universe was about 10 billion years.

While other theories about the early history of the universe have emerged over the years, the scientific world in general settled for the Big Bang theory after the discovery of some important evidence in 1965. In its early phases, the Big Bang is thought to have consisted of a very hot and very dense gas of elementary particles first and hydrogen and helium later. In this gas, light emitted from a particle could not travel far before encountering another particle, when its direction and frequency would be changed. Thus, if it had been possible to look at the early universe from the outside, one would have been able to see only its outermost layers; the universe was non-transparent.

As a result of the continuing expansion of the universe, eventually its density had decreased far enough to enable radiation emitted from a particle to travel through most of the universe without encountering another particle. At that moment the universe became transparent. The universe was then about 300,000 years old. This is a very young age; 300,000 years of a total of some 15 billion is equivalent to two hours in the life of a 50-year-old person. Already in the 1940s, Gamow, Alpher, and others had foreseen this situation and had calculated that radiation emitted at that epoch should be able to reach us today unmodified and, thus, inform us about the condition of the universe at that time.

Then, in 1965 two radio engineers working for the Bell telephone company made an unexpected discovery. They found some strange noise reaching their radio antenna and, after analyzing it, concluded that it came from a source of radiation that was uniform over the whole sky and had a temperature of only 3 K. It was soon realized that this was the radiation emitted at the time the universe became transparent. This discovery provided very strong support for the Big Bang theory and convinced most cosmologists of its validity.

This 3 K radiation, or cosmic microwave background radiation (CMB), seemed to have the same intensity in every direction. This meant that it originated from places at the same temperature and density. This was a problem. In such a uniform medium, how could the present-day structures of the universe—stars, galaxies, superclusters of galaxies—be formed? This structure represents inhomogeneities that should have been present from an early date because once a medium is completely homogeneous, it is impossible to introduce inhomogeneities into it without referring to an outside influence.

Since these early conclusions were reached on the basis of ground-based observations, with all their uncertainties introduced by the passage of radiation through the earth's atmosphere, plans were made for a satellite that could observe from space and reach a higher accuracy. Thus, the COsmic Background Explorer satellite (COBE) was launched in 1990. By 1992 its results had been analyzed and small differences in temperature had been detected when looking in different directions. These small fluctuations in temperature, and thus density, seemed sufficient to explain the formation of galaxies and other structures. As a result, in its broad lines, the Big Bang theory was accepted by the great majority of cosmologists and, with the help of the media, by many other people as well. It is doubtful whether the Big Bang model would have met with such general interest if it had been just a model for the origin of the physical, inanimate universe.

By attempting to explain the origin of matter found in living beings, the Big Bang theory has become involved with the theory of naturalistic biological evolution. Thus, during the first three minutes, when the universe was very hot and dense, it is believed that only the simplest chemical elements—mostly hydrogen and helium—were formed. When this had been achieved, the temperature had decreased so far that further manufacturing of nuclei of chemical elements—nucleosynthesis—was no longer possible. Therefore, the question about the origin of chemical elements important for life—like oxygen, nitrogen, carbon, calcium, and many others—that are also found in the Earth, becomes one of the most interesting in modern cosmology.

The process of nucleosynthesis

After the first 300,000 years—according to the Big Bang theory—when the universe became transparent, gravitational forces still let their influence be felt. Under this influence, small inhomogeneities started to grow by attracting surrounding matter. Eventually this led to the formation of large clouds composed mainly of hydrogen and helium. These contracted further, and the temperature in their centers rose as a result. When the central temperature in these objects reached a temperature of about 10 million K, nuclear processes were ignited. Hydrogen began to be transformed into helium with the production of much energy that became visible as radiation, and stars were "born." Thus, stars shine because of the nuclear processes in their centers. Although stars are huge, the amount of nuclear fuel—hydrogen—they contain is not limitless. By the time a major proportion of the hydrogen has been used up, the central part of the star collapses, and the temperature increases to about 25 million K. At this temperature, the helium that has so far been inert, can be used as fuel for a next stage of nucleosynthesis that converts helium into carbon.

This process is repeated several times, with each cycle taking less time than the previous one, until the chemical elements up to and including iron have been formed. It then depends on the mass of the star what happens next. If a

star is massive enough, it will explode as a supernova, producing many elements heavier than iron in a very short time. In the explosion, a major proportion of the star's matter is returned to space, where it can form into large clouds from which another generation of stars can be formed. Eventually, and quite likely in more than one place, planets composed of solid matter, including the Earth itself, are formed. At this point, the processes of naturalistic evolution are supposed to have taken over to generate life and develop it into intelligent living beings. So much for the Big Bang.

There is much in the Big Bang model with which Christians can identify. The early universe was dominated by radiation and light, reminding us of what happened on the first day of Creation week. Adam was formed from material available on earth, i.e. from the dust of the ground. The sun, moon and stars were made when many other things in the universe were already there: the fourth day comes after "the beginning." Unfortunately, for the Big Bang that is, there are also many discrepancies with Genesis 1: The first 300,000 years when the universe was filled with light cannot really be compared to the first day of Genesis; life is not created but evolved from inanimate matter; far more than six days are required for the completion of the process, etc.

Scientific and philosophical problems

Apart from the differences between cosmology and Genesis, I perceive scientific and philosophical problems within the Big Bang model itself. These can briefly be listed as follows:

Scientific problems. First, the cause of the redshift is not necessarily the recession of the galaxies. There are other phenomena that can cause a redshift. Among these, the so-called "gravitational redshift" implies unbelievably large masses for the far-away galaxies; and the so-called "transverse Doppler effect" would require very rapid revolution around a center. Remembering that Ellen White wrote about "suns and stars and systems, all in their appointed order circling the throne of Deity,"[1] one should be open to this possibility, especially since revolution around a center is a wide-spread characteristic of cosmic objects. Finally there is also the idea that through interaction with matter, light would lose some of its energy during its long travel from a faraway galaxy to the Earth. In my opinion, this idea of "tired light" has never received the attention that it deserves.

Second, in the Big Bang theory, the elementary particles like electrons, protons, neutrinos, neutrons, and others, were produced in the very early moments of the universe. According to our best knowledge, well supported by laboratory experiments, such elementary particles are formed in pairs: with each particle appears its antiparticle, made of anti-matter: positrons with electrons, antiprotons with protons, etc. When a particle meets its antiparticle, the two will disappear in a blaze of energy. In the very dense universe, just after particles and antiparticles had been formed, it would have been inevitable that each particle should have met its antiparticle. As a result the universe would have been full of radiation and devoid of matter, except for such particles as neutrons that have no antiparticles. However, there *is* a lot of normal matter in the universe. Either there must have been some asymmetry in the production of elementary particles—with more normal particles than antis formed, or about half the universe must consist of anti-matter, carefully isolated from the normal stuff. But there is no hint of this.

Philosophical problems. First, although the condition of the universe during the first 300,000 years of its existence is not open to direct observation, we can note its condition at that age from the CMB and, assuming that the expansion occurred also before that time, extrapolate back toward earlier epochs. Going back in time in this way, we find an ever-denser and hotter universe where we have to apply increasingly less well-understood physical principles in order to understand what is happening. Inevitably, we come to a point in time before which the universe was so dense and hot that even our most-advanced knowledge of theoretical physics can no longer cope with the extreme conditions. We arrive at this point when we are only 10^{-43} seconds from the zero point, the beginning of time and space.

The incomprehensible condition of the universe during this first fraction of a second is called a singularity. One might consider that such a small fraction of a second can be overlooked and that we can now triumphantly announce to have reached the beginning of time. But the problem is that at an age of 10^{-43} seconds the universe is supposed to have already contained a lot of matter and that, as a result, we have not really come much closer to understanding where all this comes from. Some say that this "primordial" matter is the result of a previous phase of the universe when it collapsed after having expanded initially. Thus, one can invoke a universe that goes through repeated cycles of expansion and contraction, with our universe just being the present version. This so-called "oscillating universe" does not really answer the question about its origin. Saying that there has always been a universe either robs it of any purpose, or makes it equal with the eternal God of the Bible. Neither alternative is acceptable to the Christian. Others, being more honest, have pointed out that it is possible to create matter from energy. The obvious question remains, of course, Where did that energy come from? In my opinion, an almighty, all- powerful God is the only real answer.

Second, the development of the Big Bang theory over the past 70 years has been full of philosophical assumptions that, according to the rules of purely sci-

entific reasoning, should not be part of the scientific process. Among these the following should be mentioned. (1) The expansion of the universe is based on a biased philosophy. In his interpretation of the redshift, Hubble adopted the validity of the Theory of General Relativity (not such a bad choice) and the Cosmological Principle—the universe looks the same from wherever it is observed. While this seems a reasonable assumption to make—in fact, the only one that can usefully be made—its validity on any known scale is not, and may never be, confirmed. (2) The Big Bang theory is based on the presupposition that science is capable of explaining everything, of answering all our questions. This is an unprovable assumption, and those who believe in God know that it cannot be correct: Science has no good answers to questions about the origin of love and hate, joy and sadness, truth, beauty, conscience and lots of other human characteristics. (3) Various alternative theories have been rejected, often without a proper investigation into their claims. So-called unscientific theories, i.e., theories that contain elements of philosophy or religion, are rejected out of hand. By taking this attitude, cosmology has condemned itself because it, too, has incorporated certain philosophical, unscientific assumptions. And, worse, cosmology has closed its eyes to what could very well be an essential part of reality and of the universe.

This is best seen in what I consider cosmology's unspoken but very clearly understood dogma that the God of the Bible and of Calvary does not exist, and that whatever god we believe in is one of our own making. Again, for Christians this is unpalatable stuff.

Conclusion

On the basis of the above, we must conclude that modern cosmology, represented by the Big Bang theory, may have its virtues in explaining numerous aspects of the physical, inanimate universe, but that it is a poor model when it comes to explaining everything, and that it leaves too many of our questions unanswered.

As Robert Jastrow concludes in his book, *God and the Astronomers:* "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 up over the final rock, he is greeted by a band of theologians who have been sitting there for centuries."[2]

So, is it possible to harmonize modern cosmology with the Bible? Should one even try to do so? And, if Yes, how can it be done? Notwithstanding the above critical look, let me state that I admire the scientific method and enterprise. We have learned much about nature that can help us to live more comfortable lives. Furthermore, science is one of God's methods of communicating with us about Himself and His plan for us. "The heavens" still "declare the glory of God" (Psalm 19:1). But there are at least two problems with this channel of communication. Sin has marred God's handiwork so that it reflects God's character but dimly. And our understanding of nature, and of the One who wants to reveal Himself through it, is incomplete as long as there are still shortcomings in our knowledge about the laws of nature that should help us to interpret God's message correctly. At the same time, let us not forget that we cannot retreat into the ivory tower of theology and explain everything around and about us from the Bible alone.

In fact, it is precisely because our incomplete understanding of both the laws of nature and of the laws of God that we often perceive the two as in conflict. But God is the author of both, and there can be no conflict if things are understood correctly. We need both disciplines in order to make sense of the universe in which we live. Albert Einstein once said, "Religion without science is blind; and science without religion is lame."[3]

Exactly how we are to combine the findings of science with our understanding of the Bible in our efforts to obtain answers to our questions about beginnings remains difficult. I believe that God created the universe. "In the beginning" may well mean that He started His creative work long ago. Cosmology, if rightly understood, tells us how God went about the job of preparing a planet with sufficient dust of the right chemical composition to form human beings and keep them alive. Then God rounded off His creation work. In six days He prepared the earth for being inhabited and then created many living creatures among whom humankind was to take a very special place.

The rest of the Bible tells us what happened next and how, despite our rebellion, God's magnificent plan will finally be achieved in those who accept the redemption that is offered through Jesus Christ. The fulfillment of this plan includes the opportunity to learn the real truth about the universe, and I will gladly change my opinion when the Creator tells me He did it otherwise.

Mart de Groot (Doctor in Natural Sciences, University of Utrecht) is senior research associate at the Armagh Observatory in Northern Ireland. Dr. De Groot was profiled in Dialogue *3:1 (1991), pp. 18-19. His postal address: 2 Sandymount Road; Richhill, Co. Armagh; BT61 8QP Northern Ireland; United Kingdom. E-mail: mdg@star.arm.ac.uk*

Notes and references

1. Ellen G. White, *The Great Controversy* (Mountain View, Calif.: Pacific Press Publ. Assn., 1911), pp. 676-678.
2. Robert Jastrow, *God and the Astronomers* (New York: W. W. Norton & Co., 1978).
3. P. Frank, *Einstein: His Life and Times* (New York: Alfred A. Knopf, 1947).