BY MART DE GROOT *

THE SEARCH FOR A PLAUSIBLE COSMOLOGY

Science and religion need to integrate their knowledge for a clearer worldview.

Modern cosmology had its origin in the 1920s when the American astronomer Edwin Hubble found that almost all galaxies—Milky Way systems like our own—show a so-called "red shift." That is to say, the color of the light we receive from a galaxy is redder than when it left that galaxy. The simplest way to interpret this is by assuming that this is a manifestation of the Doppler effect: A light source moving away from an observer on Earth will look redder than it did at its source. When Hubble started to interpret his observations, he did not immediately rely on the Doppler effect for an explanation because he wanted to keep open the possibility of alternative explanations.

Models of the universe into which the new findings could be fitted included one by Milne and another by Lemaltre, both of which allowed an expanding universe. The idea of an expanding universe agreed with Einstein's Theory of General Relativity (GR). Although other viable models existed, since

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If today the universe is expanding, then it must have been smaller in the past. In the light of this, moving back far enough in time, one would arrive at a moment when the universe had some minimum size from which it expanded. It seemed that in this way it was possible to arrive at the beginning of time. Christians soon recognized this as a possible way of understanding the opening statement of the Bible: "In the beginning God . . ."

Hubble was eager to include GR in his explanation, he soon abandoned his initial reservations, adopted the Doppler effect as a valid explanation, and concluded that most galaxies are moving away from us. Thus, the term "expanding universe" came into being.

Further steps suggested themselves quite easily: If today the universe is expanding, then it must have been smaller in the past. In the light of this, moving back far enough in time, one would arrive at a moment when the universe had some minimum size from which it expanded. It seemed that in this way it was possible to arrive at the beginning of time. Christians soon recognized this as a possible way of understanding the opening statement of the Bible: "In the beginning God . . ."

Dating this beginning was more complicated. It required the measurement of both the rate of the expansion and its possible variation in time. Since the light from distant galaxies requires long periods of time to reach us, the observation of such distant galaxies allows us to determine the rate of past expansion. Telescopes available to Hubble in the 1930s, however, were not powerful enough to see objects at very large distances, and, consequently, the first estimates of the age of the universe came out at around 2 billion years. For Christians prepared to see the first two verses of Genesis 1 as distinct in time from the rest of that chapter, this did not cause alarm. Even the later construction of larger telescopes and the subsequent better estimates of the age of the universe as some 15 billion years did not immediately cause too much concern for many Christians.

The Big Bang Theory

Concerns were raised, however, when details of the now widely adopted Big Bang theory were worked out. It soon became clear that this theory was on course to allow long periods of time not only for cosmological structures but also for biological evolution to have ample time for its slow developments and changes. Besides that concern, however, an important objective difficulty for the Big Bang is immediately apparent: Basic to the theory is the sudden expansion of so-called "primordial matter." But what is the origin or source of this matter? Although a number of complicated hypotheses have been suggested, no satisfying answers to this question have yet been found. In the light of this, at the start there is ample room for a creative act outside the realm of scientific or physical observation.

Now another interesting aspect in the Big Bang presents itself. After the rapid expansion of the particles composing the primordial matter that lasted only a fraction of the universe's first second, conditions were ripe for the production of the better-known building blocks of the cosmos: constructive chemical elements. These elements were produced in pairs. Each normal particle came with its antiparticle, both containing the property to destroy the other in a flash of radiation, upon encounter. In the highly dense conditions of the early universe, such encounters could not have been avoided, and, as a result, all matter would have been annihilated by antimatter, making it forever impossible for the known chemical elements to be produced. The only way to avoid this would have been for a surplus of normal matter over antimatter to have been produced in the first few seconds. It is possible, in fact, to estimate fairly accurately what the surplus should have been. For every one billion pairs of matter and antimatter particles, one more normal particle was needed. There is no good physical explanation for the presence of this asymmetry. Nor does one feel comfortable suggesting that nature has a preference for asymmetry. Thus, one must ask the question: What or who caused this needed asymmetry?

Chemical Elements Needed for Star and Life Formation

Another question is raised by the Big Bang theory. After the first three minutes, and as a result of the rapid cooling due to its expansion, the universe became too cold for the formation of chemical elements more complex than the very simplest: hydrogen and helium with a small admixture of deuterium, lithium, and beryllium. Since most natural matter on Earth is composed of more complex elements such as oxygen, nitrogen, carbon, calcium, and silicon, one must ask how and when these more complex vital chemical elements were formed. Astrophysics—that is, physics applied to stars and galaxies—has discovered an answer. Stars shine through a series of nuclear reactions deep in

their hot interiors. In these reactions, part of the hydrogen and helium is used to build the more complex atoms.

Stars are formed from large clouds of gas in space when the gas contracts due to the action of gravity. In this contraction, the density of the cloud increases, and with it comes a rise in the cloud's temperature. This rise continues until the moment when conditions are just right for the ignition of the nuclear processes that produce both the stellar radiation and the more complex atoms. However, for clouds of gas to contract, at least two conditions need to be fulfilled.

First, the gas needs to have certain inhomogeneities—regions where matter is slightly more dense than elsewhere—so that these can be the centers for gravity's star-contracting action. Since the universe's primordial matter was spread out very evenly during the period of inflation, it was not obvious how these inhomogeneities could have arisen.

To investigate this situation, the Cosmic Background Explorer Satellite (COBE) was launched in 1990. Its task was to measure the amount of radiation produced from different parts of space when the universe was only some 300,000 years old. At that time the temperature of the universe had already decreased from its initial high. As mentioned earlier, further expansion since then has cooled the universe to much lower temperatures. The COBE measurements of this temperature show that the temperature is not the same in all directions. Where it is slightly higher, it betrays the existence of slightly denser matter, just enough to allow gravity to do its work of contracting clouds of gas into stars. Again, though it is unclear how these inhomogeneities formed, their presence provides important support for the Big Bang theory; unless, of course, one invokes an apparently necessary act of God to introduce the inhomogeneities into an otherwise perfectly homogeneous medium.

Second, at the time stars and galaxies were formed, the expansion of the universe must not have been so rapid that the outward-directed expansion could not be overcome by the inward-directed action of gravity. On the other hand, the expansion must not have been too slow, because in that case, gravity would already have overcome expansion, and the universe would not be expanding and could even have collapsed into itself before now. Thus, the force behind the original expansion must have been subject to some very fine tuning: one part in 10^{49} (i.e., a 1 with 49 zeros) is what is needed. Again, one is constrained to ask what or who was responsible for such incredible fine tuning?

Assuming, with Big Bang cosmol-

In all of this, could it be that there is some connection between the way human beings came into existence and the chemical elements essential to life, which according to the Big Bang theory were made deep inside stars? Might there be some connection between the process of star making and the "dust of the ground" referred to in Genesis 2:7 (KJV) and its role in the advent of human life?

ogy, that at some time during its existence the universe brought forth stars, it becomes relatively easy to conceive how things developed further. Deep in the interior of stars, hydrogen is burned at very high temperatures and slowly converted into helium. When most hydrogen has been used up in this way, the core of the star collapses, and its temperature rises dramatically. At this heightened temperature, helium is ignited, forming carbon. From here, successive stages of nuclear burning produce the chemical elements up to iron.

More complex elements beyond iron are formed when massive stars explode at the end of their existence as energy-generating entities, that is, when stars "die." Dying stars return much of their matter to the environment. At this point such matter is no longer composed of hydrogen and helium only. Through the dying process it has been enriched with other, more complex, chemical elements. The gas that has been returned to space can give rise to the next generation of stars when, again, gravity contracts gas clouds into energy-generating objects. Each time a star is formed from a gas cloud, some matter at the periphery of the cloud is not captured by the star but remains in orbit around it and can form planets. In this way it is possible to understand how planets composed of iron, nickel, silicon, manganese, et cetera can form in a universe originally composed only of hydrogen and helium.

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Probably the most serious shortcoming of the Big Bang is its inability to go back to the very beginning of time and space. Though the condition of the universe seems to impede our looking back farther than when it was already 300,000 years old, theoretical extrapolations have allowed scientists to pronounce upon much earlier conditions right to the first second. However, limitations imposed by physical theory do not allow us to analyze what happened in the very first tiny fraction of a second.

came into being in terms of the Big Bang theory, could this suggest a plausible path for the process of biological development? Could the scenario painted by the Big Bang theory be something initiated and guided by a Creator, thus outlining a complete description of how life on Earth came into being?

This is not the place to discuss the shortcomings of the theory of biological evolution. Suffice it to point out that we have just identified an additional hurdle for this theory to negotiate when we noted that biological evolution is a non-self-starter if it is not preceded by physical evolution—the formation of elementary particles as the building blocks of all matter. Along with this we have noted that, by its nature, biological evolution also depends on chemical evolution—the production of the more complex chemical elements essential to life. If one would like to believe that the above processes are just the way God acted in His creative works, then it becomes necessary to accept the long-time scales of billions of years required for bringing these processes to completion, an option not contemplated by the Genesis account when it deals with the origin of life.

Problems With the Big Bang Theory

The credibility of the Big Bang depends on the solidity of its supporting pillars. The first among these are the redshifts. If these are to be interpreted as a Doppler effect, then the conclusion of an expanding universe seems inescapable. But it must be remembered that Hubble's choice of the Doppler effect for the explanation of his observations was based in part on philosophical arguments. Hubble assumed the validity of GR and of the so-called Cosmological Principle (CP).

Recently, however, GR has come to be questioned by the discovery that faraway galaxies are receding faster than predicted by Einstein's original theory. It seems that, though gravity attracts over large distances, at the very large distances we find in the universe, it turns into a repellent force. This requires the addition of the so-called "cosmological constant" to the law of gravity and, thus, a revision of the Big Bang theory. It is not yet clear how the Big Bang will come out of this process.

The CP postulates that, generally speaking, the universe looks the same from every location within it. At the same time it is reasonably assumed that the laws of science as we have come to know them on Earth operate in the same way throughout the universe and at all times. Although this is the only assumption one can make if sense is to be made out of our astronomical observations, it is a philosophical assumption and it does introduce a form of uniformitarianism that would seem to exclude divine intervention in the affairs of the cosmos.

Another problem with the choice of the Doppler effect to explain the redshifts is that these can also be produced in different ways not requiring a recession of the galaxies. Among these, theories of tired light may hold some promise. The idea is that a photon—a single packet of light—on its long travel through the universe will suffer some interaction with particles in space and thus lose some of its energy. This loss of energy manifests itself as a redshift. Since space is not empty—although very sparsely populated with only a couple of hydrogen atoms per cubic meter—the farther the photon travels, the more it becomes redshifted. That's exactly what is observed. Unfortunately, tired-light theories have not been given the attention they merit because of the early popularity of the Doppler effect as an explanation for the redshift. This popularity has in fact caused a neglect of many alternatives.

As mentioned earlier, probably the most serious shortcoming of the Big Bang is its inability to go back to the very beginning of time and space. Though the condition of the universe seems to impede our looking back farther than when it was already 300,000 years old, theoretical extrapolations have allowed scientists to pronounce upon much earlier conditions right to the first second. However, limitations imposed by physical theory do not allow us to analyze what happened in the very first tiny fraction of a second. It seems that what happened during the first 10^{-43} seconds (a number with 42 zeros behind the decimal point) will forever remain a scientific mystery. Thus, the question about the origin of primordial matter is not answered. And it does not

help to say that primordial matter was made out of energy because that only begs the question: Where did that energy come from?

God's Revelation on Origins

For Christians who want to base their faith on God's revelation in the Bible, there is plenty of scope. Despite its desire to be a theory that explains everything, the Big Bang has so many weak points that there is still ample room for God to play His role. Not that this is the way we should introduce God into our thinking about origins, because if at some future date, science answers some of these questions, we might be forced to abandon part of our way of explaining God's role in the creation of the universe. Our relationship with God should not be based on *His* ability to answer *our* questions about the universe (although the ultimate answers do rest with Him) but on the kind of God He is as revealed at Calvary and in His dealings with His creation.

Of course, such a view of God does not answer all our questions about the origin of the universe. What exactly happened during Creation week, especially on the fourth day, is still a mystery. Science says that the Sun is some five billion years old. The Bible seems to suggest that our Sun was created at about the time our Earth was. A similar question concerns the rest of the universe—the stars and galaxies. As long as we do not possess the scientific knowledge that we have been promised will eventually be ours after we have arrived safely in God's eternal kingdom, and as long as we are still struggling to find the correct interpretation of many a Bible passage, these questions will not be answered. But our look at the Big Bang does allow us to say "it ain't necessarily so." We would do well to heed Albert Einstein's famous statement, "Science without religion is lame, and religion without science is blind," and integrate more fully these two areas of knowledge. Thus, more progress is to be made when we interrogate the universe, not about its origin, but about the One who designed and created it. Because that is how "The heavens declare the glory of God" (Ps. 19:1, KJV). □