Origin of the universe essay sample

Introduction

During the last few years, there has been a series of exciting new discoveries in the fields of cosmology and particle physics, and scientists are at last beginning to understand the origin and evolution of the universe and the basic constituents of matter. These discoveries have been accompanied by a great deal of speculation. Scientists try not only to determine what is true; they also try to discover what might be true. Naturally there is nothing wrong with speculating in this manner. Before one can tell what the cosmos and the micro world are like, it is necessary to find out what the possibilities are. (Maxwell, Nicholas, pg 5-6)Source: Space. com

Scientific knowledge has increased at such a rapid rate that some of this speculation has become quite astonishing. For example, scientists now have direct empirical evidence about the nature of the universe back to a time of about one second after the beginning of the big bang. This has led them to develop detailed theories about what might have been happening during that first second. Some have gone even further and have tried to invent plausible scenarios describing the creation of the universe. Others have wondered whether there might not be countless other universes besides our own.

Similarly, scientists have probed so deeply into the basic structure of matter that they are no longer content with discovering new subatomic particles and trying to understand their behavior. They are speculating about the nature of reality at an even more microscopic level, and attempting to probe into the very nature of space and time. They have begun to wonder if there might not be more dimensions of space than the three that we know, and have constructed theories about ten- and eleven- dimensional objects called superstrings and membranes.

One result of all this activity has been the publication of numerous books describing recent scientific speculation and discoveries. Ordinarily, great emphasis is given to the newest ideas. This is as it should be. Any book that failed to discuss them would quickly be out of date.(Aczel, Amir D, Pg 10-11)

Many of the new ideas are quite appealing. If they are eventually confirmed, we will advance to new levels of scientific understanding, and our conceptions of both the universe and the micro world will be transformed. However, there are drawbacks associated with the emphasis on newly developed concepts that is characteristic of many books. The average, non-mathematically trained reader frequently finds it difficult to distinguish between scientific fact, partially confirmed hypotheses, and inspired guesses.

When astronomers look 10 billion light years out into space, they are also looking 10 billion years back in time. As a result, they have been able to obtain a clear picture of the evolution of the universe from a time when it was very young. There are other kinds of observations that can be made that allow scientists to observe the universe when it was even younger. For example, the earth is bathed by radio waves coming from every direction of space. This cosmic microwave background radiation is made up of energy that was emitted in the form of ‘ bright light in the aftermath of the big bang, when the universe was about 300, 000 years old. Over the course of billions of years, this light has been degraded into what are called microwaves (radio waves of short wavelength). Thus scientists can literally see the dying glow of the big bang. Source: Science. com

But 300, 000 years does not represent a limit. Scientists have direct empirical evidence concerning the state of the universe down to a time of one second after its creation. Naturally, they cannot observe the early universe visually. Any light or other radiation that was emitted at a very early time would have been absorbed and re-emitted by the matter in the universe so many times that the chances of actually seeing what was going on are nil.

However, scientists can measure the quantities of certain chemical elements that could only have been created when the universe was very young. These elements cannot be created in stars; the high temperatures and energies in stellar interiors would have caused them to break apart as soon as they were made. Nuclei are broken up, as well as formed inside stars. Thus, by studying the abundances of these elements, astrophysicists are able to gain an understanding of the processes that were taking place when the universe was as young as one second old.(Khorsandian, Rostam, 137)

Big Bang Theory

Like the impressionist movement in painting, the big bang theory of the origin of the universe was given its name by a hostile critic. On a radio broadcast in 1950, the English astronomer Fred Hoyle derisively referred to the big bang theory. According to the rival steady state theory of the universe, which had been proposed by Hoyle and physicists Thomas Gold and Hermann Bondi, the universe had no beginning in time; it had always existed.

Today, of course, we know that there was a beginning. The universe came into existence some 10 to 15 billion years ago. It was initially in a very hot, highly compressed state, and it has been expanding ever since. Although it is impossible to say what was happening at time zero, we know that when the universe was one second old many of the atomic nuclei that exist today were already being formed. At the time, the universe was a hot, glowing fireball, and was rapidly cooling as it expanded. There are three kinds of evidence that enable scientists to reach this conclusion. The first of the three is probably the weakest: the fact that the universe is expanding today. Observations of distant galaxies show that galaxies and clusters of galaxies are moving apart. It seems only reasonable to suppose that there must have been a time when all of the matter in the universe was compressed in a small space. But this piece of evidence is not conclusive. It is possible to devise theories in which the universe did not originate with a big bang, but is expanding nevertheless.

In fact, this is precisely what Hoyle, Gold, and Bondi proposed. They knew very well that the universe was expanding, but they assumed that, as it did, new matter was created in intergalactic space. In time, this matter would accumulate, and new galaxies would be formed. They were thus able to avoid the problem of a beginning. To be sure, no one had ever seen matter pop into existence. However, the steady state theory required only that one new hydrogen atom be created in each cubic meter of space once every 10 billion years. The proposed rate of creation was much too small to be observable. lot of scientists found the idea of a steady state universe to be appealing. The theory avoided the problem of having to explain how the universe began. According to Hoyle, Gold, and Bondi, it had always existed. However, the theory was discredited in 1964 when two Bell Laboratories radio astronomers, Arno Penzias and Robert Wilson, discovered that microwaves — short radio waves — were falling on the earth from every direction. The intensity of the microwave radiation was the same in every section of the sky Penzias and Wilson examined, and it did not vary according to the hour of the day or night.

Many years previously, the Russian-American physicist George Gamow had predicted that, if the big bang theory were correct, then the earth should be bathed with microwave radiation like that which was discovered by Penzias and Wilson. In 1949, together with his students Ralph Alpher and Robert Herman, he had published a paper in which he predicted that it should be possible to observe a relic of the big bang in the form of blackbody radiation with a temperature of about 5 degrees Kelvin (degrees Celsius above absolute zero). By the time that Penzias and Wilson made their discovery, the work of Gamow and his students had been forgotten. However, a group of cosmologists working at Princeton University consisting of physicist Robert Dicke and his colleagues had rediscovered Gamow’s result. The universe was created 10 to 15 billion years ago, and it has been cooling ever since. When the light from the big bang fireball was emitted, the universe had a radiation temperature of about 3000 degrees Kelvin. It has a temperature of about -270 degrees Celsius today. Scientists generally express this as 3 degrees Kelvin, since absolute zero, the temperature at which all molecular motion ceases, is -273 degrees C (the radiation temperature is actually known quite precisely; the exact figure is 2. 726 degrees). This doesn't quite agree with Gamow's prediction of a 5 degree temperature, but his estimate was remarkably close for 1949.

Observing the microwave background radiation allows scientists to see the universe as it was when it was only 300, 000 years old. We know that the radiation was emitted at that time because the temperature of the universe was previously too high for electrons to form atoms by attaching themselves to hydrogen and helium nuclei. There was so much radiation energy in the universe that atoms would have been broken apart as soon as they formed. This prevented light from traveling any great distances. Light rays If the best that we could do was to determine what the universe was like at an age of about 300, 000 years, trying to understand what was going on before that time would involve a lot of guesswork. However, it is not necessary to make guesses. Scientists can, in fact, see the universe at an age of one second. It was at this time that certain light atomic nuclei began to be created. Measurements of the quantities of these nuclei that exist today provide direct observational evidence about the early universe.(Fox, Karen C. 10-25)

Originally, the universe contained only basic particles of matter such as protons, neutrons, and electrons. Then, when it had reached an age of about one second, helium nuclei began to be created in large quantities. A helium nucleus consists of two protons and two neutrons. It was formed from the protons and neutrons that existed in the early universe. The helium that scientists observe today could not have been created in stars. Although 10 to 15 billion years have passed since the universe began, there has not been enough time for stars to create the quantities of helium that are seen. At best, the nuclear reactions that take place within stars could have created only about 10 or 15 percent of the helium that is known to exist.

Measuring the chemical composition of stars, galaxies, and of interstellar or intergalactic gas is not very difficult. Each chemical element emits light at certain characteristic wavelengths when it is heated, and it is only necessary to study the light (or radio waves in the case of gas) emitted by an object to determine what it is made of. When these measurements are performed, it is found that the universe is about 25 percent helium and about 75 percent hydrogen by weight. All of the other elements exist only in relatively small quantities.

The nuclear reactions that take place within stars are well understood, and it is possible to calculate the quantities of helium that they have produced. It is impossible to avoid the conclusion that most of the helium that is seen must have come from somewhere else. That somewhere else could only have been the big bang fireball. This line of reasoning is confirmed by the fact that smaller quantities of helium are found in older stars. Old stars generally contain 2 to 3 percent less helium than our sun, which was formed only 5 billion years ago.(Sargent, Jo, 78)

Conditions in the early universe can be determined in several different ways. For example, trace amounts of deuterium exist in the universe. Deuterium is an isotope of hydrogen; it has the same chemical behavior that hydrogen has, but a different number of particles in its nucleus. A hydrogen atom consists of a single proton that is orbited by a single electron. A deuterium nucleus consists of a proton and a neutron. Since the electrical charge is the same in either case only a single negatively charged electron will attach itself to the nucleus.

Deuterium cannot be made in stars. The proton and neutron are too weakly bound to one another. If any deuterium is formed in a star, the high temperatures will cause it to quickly break apart. Since deuterium cannot come from stars, it must have been created in the big bang fireball, where conditions were somewhat different. To be sure, some deuterium nuclei were broken up at that time. However, the universe cooled rapidly during the early stages of its expansion and many deuterium nuclei survived.

Finally, a few other light nuclei were created in the big bang in trace amounts. These include helium-3 (two neutrons and a proton), lithium-6 (three neutrons and three protons), and lithium-7 (four neutrons and three protons). None of the heavier elements were created at this time. The necessary conditions for their formation did not exist.

Nucleosynthesis — the creation of light atomic nuclei -took place when the universe was about one second to three minutes old. After that these processes stopped. The temperature of the universe had fallen to the point that the energy required to stick sub nuclear particles together was no longer available. And of course the energy required to break nuclei like deuterium apart just wasn’t there either. A deuterium nucleus can be split if it undergoes a collision with another particle. But if the other particles, or the radiation that is present, do not possess enough energy to make this happen, it survives. There is, of course, a relation between temperature and the energy of individual particles. For example, the temperature of an object encountered in everyday life is a consequence of the motion of its constituent molecules. In the early universe, temperature is measured by the motion of energetic particles (e. g., protons and neutrons) instead. (Szadkowski, Joe, pg 5)

One thing that scientists cannot do is observe the evolution of the universe before a time of one second. They must depend upon theory instead. However, there is a point at which all theories break down. Newton's law of gravitation cannot accurately describe the things that happen when gravity is very intense. Scientists must use the general theory of relativity instead. However, general relativity breaks down too when quantum effects become important. It is incompatible with quantum mechanics, the theory which is used to describe the behavior of subatomic particles.

In fact, if one attempts to use general relativity to extrapolate all the way back to the beginning of the universe, one obtains a result that is nonsense. It is possible to prove mathematically that if general relativity is a correct theory, then the universe must have begun in a state of infinite matter density. Now, whenever infinity appears in a theory, this is generally a sign that something has gone terribly wrong. In fact, the impossibility of infinite quantities is sometimes used to prove certain results. According to Einstein's special theory of relativity, the theory that describes the behavior of objects that are traveling at high velocities, an infinite quantity of energy would be required to accelerate an object to the speed of light. This is generally taken to be a proof that no material object can ever travel at light velocity.

If we wanted to know what was happening at the moment of the creation of the universe, a theory of quantum gravity, one which combined quantum mechanics and relativity would be required. But no such theory has ever been found. Theories about the origin of the universe must therefore be of a speculative nature.

Many physicists believe that general relativity accurately describes the evolution of the universe back to a time of 10-43 seconds after the beginning. This is the time when quantum effects would have ceased to be important. When I speak of quantum effects I am not referring to the gravitational effects of whatever high-energy particles were present, but of alterations in the very nature of space and time. If quantum mechanics is a correct theory than there is no reason to think that there is no such theory–then space and time must originally have had a character somewhat different than that which is observed today. Unfortunately, no one knows what these alterations of space and time were like, only that they should have existed for a short moment after the universe was born.

There is also another note of uncertainty. As I noted previously, general relativity has never been tested in gravitational fields like those that presumably existed at early times. Gravity of that strength simply does not exist in the present day universe. Thus any theory that attempts to describe the universe at very early times must make use of an unproven idea, that general relativity will continue to be valid whenever quantum effects are unimportant. Scientists know of no reason why general relativity should break down before that point is reached. However, using it under such circumstances requires an act of faith.(Maxwell, Nicholas, 110-113)

Inflationary Universe Theory

The best-known theory of the early universe is the inflationary universe theory, which was discovered by the Massachusetts Institute of Technology physicist Alan Guth in 1979. According to Guth, the universe underwent a period of extraordinarily rapid expansion when it was 10-35 to 10-33 seconds old. During that time, an enormous repulsive force existed in the universe, causing it to inflate to a much larger size. During this period, the volume of the universe doubled once every 10^{-35} seconds. Today the universe doubles in size about once every 10 billion years.

Since the inflationary expansion presumably took place long before a time of one second, it is impossible to perform observations that might confirm or falsify it. Nevertheless the inflationary theory is widely accepted by scientists. They know of no other theory that can explain why the universe possesses the characteristics that it has today. For example, when the universe was one second old, it had to have a matter density that was equal to a certain figure to an accuracy of fifteen decimal places. If the density had been greater than this by even a tiny amount, then gravity would have caused the expansion of the universe to cease relatively quickly. A state of contraction would have ensued, and the universe would have collapsed in a big crunch long before life had a chance to evolve. If the density had been less than the critical figure by a tiny amount, then the expansion would have proceeded so rapidly that stars and galaxies could never have formed. Matter would have been flying apart at too great a velocity.

Now it turns out that, if the inflationary universe theory is correct, the universe would have had exactly the right density. The rapid expansion that began at a time of 10-35 seconds would have fine-tuned the density of the universe in just the right way. The rapid expansion would have brought about exactly the matter density that was needed. This may sound like some kind of mathematical sleight of hand. But it really isn’t. When the equations associated with the inflationary theory are worked out in detail, it turns out that it doesn’t matter very much what the density originally was.(Ingram, David, pg 55-58)

Conclusion

Scientists are able to visualize many different kinds of possible universes. In most of them, life would never have the chance to evolve. So why is it that our universe is so hospitable to living beings? As we shall see, the creation of life is part of the story of cosmic evolution.

Bibliography

- Maxwell, Nicholas. Book Title: The Comprehensibility of the Universe: A New Conception of Science. Publisher: Clarendon Press. Place of Publication: Oxford. Publication Year: 1998.
- Aczel, Amir D. Book Title: God’s Equation: Einstein, Relativity, and the Expanding Universe. Publisher: Four Walls Eight Windows. Place of Publication: New York. Publication Year: 1999.
- Khorsandian, Rostam. Article Title: Universe as the Interaction of Its Parts with Limitations. Journal Title: Journal of Evolutionary Psychology. Volume: 24. Issue: 3-4. Publication Year: 2003. Page Number: 136+.

- Sargent, Jo. Article Title: Universe. Magazine Title: Geographical. Volume: 77. Issue: 12. Publication Date: December 2005. Page Number: 78.
- Fox, Karen C. Book Title: The Big Bang Theory: What It Is Where It Came From, and Why It Works? Publisher: Wiley. Place of Publication: New York. Publication Year: 2002.
- Ingram, David. Book Title: Critical Theory: The Essential Readings. Publisher: Paragon House. Place of Publication: St. Paul, MN. Publication Year: 1992.
- Science, All about the Universe, Viewed from http://www. space. com/universe/ on March 14, 2008.
- Szadkowski, Joe Article Title: Probing Deep into Origin of Universe.. Newspaper Title: The Washington Times. Publication Date: February 3, 2002. Page Number: 5.