UNIT 4 ORIGIN AND END OF THE UNIVERSE

Contents

4.0 OBJECTIVES

- To familiarise ourselves with some general theories on the origin and end of the physical universe.
- To know that scientific theories on the universe keep on evolving and changing.
- To be familiar with the commonly accepted theory on the origin and end of the universe (Big Bang and Big Crunch)

4.1 INTRODUCTION

According to Stephen Hawking (1988) the problem of the origin of the universe, is a bit like the old question: Which came first, the chicken, or the egg. In other words, Who created the universe? Or perhaps, the universe, or the agency that created it, existed forever, and didn't need to be created. Up to recently, scientists have tended to shy away from such questions, feeling that they belonged to metaphysics or religion, rather than to science. However, in the last few years, it has emerged that the Laws of Science may hold even at the beginning of the universe and also may explain the end of the universe.

The debate about whether, and how, the universe began, has been going on throughout recorded history. Basically, there were two schools of thought. Many early traditions, and the Jewish, Christian and Islamic religions, held that the universe was created in the fairly recent past. For instance, Bishop Usher calculated a date of four thousand and four BC, for the creation of the universe, by adding up the ages of people in the Old Testament. One fact that was used to support the idea of a recent origin, was that the Human race is obviously evolving in culture and technology. We remember who first performed that deed, or developed this technique. Thus, the argument runs, we cannot have been around all that long. Otherwise, we would have already progressed more than we have. In fact, the biblical date for the creation, is not that far off the date of the end of the last Ice Age, which is when modern humans seem first to have appeared.

The universe of 100 years ago was simple: eternal, unchanging, consisting of a single galaxy, containing a few million visible stars. The picture today is more

complete and much richer. The cosmos began 13.7 billion years ago with the big bang. A fraction of a second after the beginning, the universe was a hot, formless soup of the most elementary particles, quarks and leptons. As it expanded and cooled, layer on layer of structure developed: neutrons and protons, atomic nuclei, atoms, stars, galaxies, clusters of galaxies, and finally superclusters. The observable part of the universe is now inhabited by 100 billion galaxies, each containing 100 billion stars and probably a similar number of planets. Galaxies themselves are held together by the gravity of the mysterious dark matter. The universe continues to expand and indeed does so at an accelerating pace, driven by dark energy, an even more mysterious form of energy whose gravitational force repels rather than attracts. In this context, this unit attempts to give some of the common theories on the origin and end of the universe from scientific perspectives. The religious perspectives are not considered here.

4.2 THE ORIGIN OF THE UNIVERSE

Some of the common scientific theories explaining the beginning of the universe

Steady State Theory

Steady State Theory proposes that matter is being continuously created, at the rate of a few hundred atoms per year. This would allow the density of the universe to remain constant as it expands. It holds that the universe looks, on the whole, the same at all times and places. The Austrian-British astronomer Hermann Bondi and the Austrian-American astronomer Thomas Gold formulated the theory in 1948. The British astronomer Fred Hoyle soon published a different version of the theory based on his mathematical understanding of the problem. Most astronomers believe that astronomical observations contradict the predictions of the steady-state theory and uphold the big bang theory. The infinite duration of time was the most appealing feature of the steady state theory. Even the notion of creation was used to advantage: the failure to detect a large flux of gamma rays led to the proposal that creation preferentially took place only in dense galactic nuclei and quasars. This proposal initially met with some enthusiasm, because it appeared to solve two problems: continuous creation was revived, and an ample energy source was provided for the most energetic objects in the universe.

However, three shortcomings eventually led to the demise of steady state cosmology. First, astronomers have discovered a large increase in the number of faint radio sources as the limiting flux level is systematically decreased. The number that they estimate is well above that expected for a uniform source distribution in Euclidean space, which suggests that strong evolutionary effects are occurring at great distances. The notion of an excess number of distant faint sources did not find universal acceptance. For several years, Hoyle was able to argue that an equally plausible hypothesis was a deficit of nearby bright sources. Now, however, it seems clear with measured redshifts that the highly red shifted sources, most notably the radio galaxies and the quasars, reveal strong evolutionary effects. Equal volumes of space contain progressively more quasars and powerful radio galaxies at greater distances. Looking at evidence, explanations, rationalizations, and arguments for naturalistic origins of the universe leads to a simple conclusion. Once all of the cards are on the table, recent discoveries have given life to interpretations that are long on theory and

short on proof. To put it another way, all scientists have really proven about the origin of the universe is that they don't really know how it happened, and they may be looking at it the wrong way.

Check Your Progress I

Note: Use the space provided for your answer

1) Give an approximate size of our universe?

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2) Give a brief description of the steady-state theory.

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Big Bang Theory

The Big Bang theory is an effort to explain what happened at the very beginning of our universe. Discoveries in astronomy and physics have shown beyond a reasonable doubt that our universe did in fact have a beginning. According to the standard theory, our universe sprang into existence as "singularity" around 13.7 billion years ago. Our universe is thought to have begun as an infinitesimally small, infinitely hot, infinitely dense, something - a singularity. We don't know where it came from not why did it appear. After its initial appearance, it apparently inflated (the "Big Bang"), expanded and cooled, going from very, very small and very, very hot, to the size and temperature of our current universe. It continues to expand and cool to this day and we are inside of it: incredible creatures living on a unique planet, circling a beautiful star clustered together with several hundred billion other stars in a galaxy soaring through the cosmos.

Evidence for the Theory

First of all, we are reasonably certain that the universe had a beginning. Second, galaxies appear to be moving away from us at speeds proportional to their distance. This is called "Hubble's Law," named after Edwin Hubble (1889-1953) who discovered this phenomenon in 1929. This observation supports the expansion of the universe and suggests that the universe was once compacted. Third, if the universe was initially very, very hot as the Big Bang suggests, we should be able to find some remnant of this heat. In 1965, Radio astronomers Arno Penzias and Robert Wilson discovered a 2.725 degree Kelvin (-454.765 degree Fahrenheit, -270.425 degree Celsius) Cosmic Microwave Background radiation (CMB) which pervades the observable universe. This is thought to be the remnant which

scientists were looking for. Penzias and Wilson shared in the 1978 Nobel Prize for Physics for their discovery. Finally, the abundance of the "light elements" Hydrogen and Helium found in the observable universe are thought to support the Big Bang model of origins.

Big Bang Theory - What About God?

Any discussion of the Big Bang theory would be incomplete without asking the question, what about God? This is because cosmogony (the study of the origin of the universe) is an area where science and theology meet. Creation was a supernatural event. That is, it took place outside of the natural realm. This fact begs the question: is there anything else which exists outside of the natural realm? Specifically, is there a master Architect out there? We know that this universe had a beginning. Was God the "First Cause"?

Check Your Progress II

Note: Use the space provided for your answer

1) Give a brief description of Big Bang?

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2) What are some of the evidences for Big Bang Theory.

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4.3 THE END OF THE UNIVERSE

Theories explaining the end of the universe are the following.

Heat Death

German physicist Hermann von Helmholtz made a prediction in the year 1856 that the universe is dying. This prediction was based on the law of thermodynamics. A more thoroughgoing analysis enables this law to be generalized to all closed systems: the entropy never falls. If the universe as a whole can be considered as a closed system, on the basis that there is nothing 'outside' it, then the second law of thermodynamics makes an important prediction: the total entropy of the universe never decreases. In fact it goes on rising remorselessly. When heat flows from hot to cold, the entropy rises, but eventually the cold body will warm up and the hot body will cool down so that they reach the same temperature. When the state is achieved, there will be no

further heat transfer. The system inside the container will have reached a uniform temperature – a stable state of maximum entropy referred to as thermodynamic equilibrium. No further change is expected, as long as the system remains isolated. All physical activity in the universe tends toward a final state of thermodynamic equilibrium, or maximum entropy, following which nothing of value is likely to happen for all eternity. This one-way slide toward equilibrium became known to the early thermodynamicists as the 'heat death' of the universe.

Big Freeze

Observations suggest that the expansion of the universe will continue forever. If so, the universe will cool as it expands, eventually becoming too cold to sustain life. For this reason, this future scenario is popularly called the Big Freeze. The future of an expanding universe is bleak. If a cosmological constant accelerates the expansion of the universe, the space between clusters of galaxies will grow at an increasing rate. Redshift will have stretched ancient, incoming photons (even gamma rays) to undetectably long wavelengths and low energies. Stars are expected to form normally for 1×1012 to 1×1014 years, but eventually the supply of gas needed for star formation will be exhausted. Once the last star has exhausted its fuel, stars will cease to shine. According to theories that predict proton decay, the stellar remnants left behind would disappear, leaving behind only black holes which themselves eventually disappear as they emit Hawking radiation. Ultimately, if the universe reaches a state in which the temperature approaches a uniform value, no further work will be possible, resulting in a final heat death of the universe.

The Big Rip

A new and somewhat sinister theory about the long-term future of the universe is emerging. It has been called the "Big Rip", and it forecasts that our bodies will be literally torn apart. Its leading proponent Robert Caldwell of Dartmouth University calls it a "pretty fantastic possibility", but he and his colleagues cannot see how it can be avoided if the present acceleration of the cosmos continues. The idea is like this: the universe, driven by that mysterious force called "dark energy", or repulsive gravity, is flying apart. The furthest galaxies are moving ever further from us. But the rate of expansion is itself accelerating. The accelerating acceleration continues unchecked. Eventually the increased acceleration comes every 100 yards, and at last every foot. Finally everything explodes. "The expansion becomes so fast that it literally rips apart all bound objects," says Caldwell.

There is no need for immediate panic, since this dreadful sequence of events will not become noticeable for another 20 billion years. At this point all galaxies beyond our own, traveling much faster than light, will have flown so far away from us that they become invisible. (This is not a violation of Einstein's special relativity. The galaxies are not flying through space. In the expanding universe, space itself expands.) Our Milky Way galaxy alone can be seen. Then the Milky Way begins to fly apart, and at this point there are only 60 million years left. Long before this, of course, other events will have destroyed our Sun and planets. But imagine some part of humanity inhabiting the planets of another stellar system. When there are only three months left, these planets and their parent Sun explode. "There's about 30 minutes left before atoms and their nuclei break apart," says Caldwell, "but it's not quality time. We're not sure what happens after that. On

the face of it, it would look like time ends." Repulsive dark energy, although we know next to nothing about its cause, comprises 73 per cent of all the energy in the cosmos. It exists everywhere in the vacuum of space.

Check Your Progress III

Note: Use the space provided for your answers.

1) What is heat death theory?

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2) Give your comments on the Big Rip theory.

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Big Bounce

The Big Bounce is a theorized scientific model related to the formation of the known universe. It derives from the cyclic model or oscillatory universe interpretation of the Big Bang where the first cosmological event was the result of the collapse of a previous universe. According to some oscillatory universe theorists, the Big Bang was simply the beginning of a period of expansion that followed a period of contraction. In this view, one could talk of a Big Crunch followed by a Big Bang, or more simply, a Big Bounce. This suggests that we might be living in the first of all universes, but are equally likely to be living in the 2 billionth universe (or any of an infinite other sequential universes).

Multiverse: No Complete End

The multiverse (or meta-universe, metaverse) is the hypothetical set of multiple possible universes (including the historical universe we consistently experience) that together comprise everything that exists: the entirety of space, time, matter, and energy as well as the physical laws and constants that describe them. The term was coined in 1895 by the American philosopher and psychologist William James. The various universes within the multiverse are sometimes called parallel universes. The structure of the multiverse, the nature of each universe within it and the relationship between the various constituent universes, depend on the specific multiverse hypothesis considered. Multiverses have been hypothesized in cosmology, physics, astronomy, religion, philosophy, transpersonal psychology and fiction, particularly in science fiction and fantasy. In these contexts, parallel universes are also called "alternative universes", "quantum universes", "interpenetrating dimensions", "parallel dimensions", "parallel worlds", "alternative realities", and "alternative timelines", among others.

Cyclic Theories

In several theories there is a series of infinite, self-sustaining cycles (for example: an eternity of Big Bang-Big crunches). A multiverse of a somewhat different kind has been envisaged within the multi-dimensional extension of string theory known as M-theory, also known as Membrane Theory. In M-theory our universe and others are created by collisions between p-branes in a space with 11 and 26 dimensions (the number of dimensions depends on the chirality of the observer); each universe takes the form of a D-brane. Objects in each universe are essentially confined to the D-brane of their universe, but may be able to interact with other universes via gravity, a force which is not restricted to D-branes. This is unlike the universes in the "quantum multiverse", but both concepts can operate at the same time.

The concept of other universes has been proposed to explain why our universe seems to be fine-tuned for conscious life as we experience it. If there were a large number (possibly infinite) of different physical laws (or fundamental constants) in as many universes, some of these would have laws that were suitable for stars, planets and life to exist. The weak anthropic principle could then be applied to conclude that we would only consciously exist in those universes which were finely-tuned for our conscious existence. Thus, while the probability might be extremely small that there is life in most of the universes, this scarcity of life-supporting universes does not imply intelligent design as the only explanation of our existence.

Critics claim that many of these theories lack empirical testability, and without hard physical evidence are unfalsifiable; outside the methodology of scientific investigation to confirm or disprove. Reasons why such claims lack empirical evidence or testability according to most Multiverse theories is that other universes are in a different spacetime framework, so in principle they cannot be observed.

The logical foundation of modern science is hypothetico-deductive logic which permits a theory to propose unobservable entities if these help explain observable outcomes, either by theory based predictions (of future observations) or retroductionism (of already known observations).

False vacuum

In quantum field theory, a false vacuum is a metastable sector of space that appears to be a perturbative vacuum, but is unstable due to instant on effects that may tunnel to a lower energy state. This tunneling can be caused by quantum fluctuations or the creation of high-energy particles. Simply put, the false vacuum is a local minimum, but not the lowest energy state, even though it may remain stable for some time. This is analogous to metastability for first-order phase transitions. The possibility that we are living in a false vacuum has been considered. If a bubble of lower energy vacuum were nucleated, it would approach at nearly the speed of light and destroy the Earth instantaneously, without any forewarning. Thus, this vacuum metastability event is a theoretical doomsday event. This was used in a science-fiction story in 1988 by Geoffrey A. Landis, in 2000 by Stephen Baxter, and in 2002 by Greg Egan. According to the many-worlds interpretation of quantum mechanics, the universe will not end this way. Instead, each time a quantum event happens that causes the universe to decay from a false vacuum to a true vacuum state, the universe splits into several new

worlds. In some of the new worlds the universe decays; in some others the universe continues as before.

The big crunch

In physical cosmology, the Big Crunch is one possible scenario for the ultimate fate of the universe, in which the metric expansion of space eventually reverses and the universe recollapses, ultimately ending as a black hole singularity. If the universe is finite in extent and the cosmological principle (not to be confused with the cosmological constant) does not apply, and the expansion speed does not exceed the escape velocity, then the mutual gravitational attraction of all its matter will eventually cause it to contract. Because entropy continues to increase in the contracting phase, the contraction would appear very different from the time reversal of the expansion. While the early universe was highly uniform, a contracting universe would become increasingly clumped. Eventually all matter would collapse into black holes, which would then coalesce producing a unified black hole or Big Crunch singularity.

The Hubble Constant measures the current state of expansion in the universe, and the strength of the gravitational force depends on the density and pressure of the matter and in the universe, or in other words, the critical density of the universe. If the density of the universe is greater than the critical density, then the strength of the gravitational force will stop the universe from expanding and the universe will collapse back on itself. Conversely, if the density of the universe is less than the critical density, the universe will continue to expand and the gravitational pull will not be enough to stop the universe from expanding. This scenario would result in the 'Big Freeze', where the universe cools as it expands and reaches a state of entropy. Some theorize that the universe could collapse to the state where it began and then initiate another Big Bang, so in this way the universe would last forever, but would pass through phases of expansion (Big Bang) and contraction (Big Crunch).

Recent experimental evidence (namely the observation of distant supernova as standard candles, and the well-resolved mapping of the cosmic microwave background) have led to speculation that the expansion of the universe is not being slowed down by gravity but rather accelerating. However, since the nature of the dark energy that drives the acceleration is unknown, it is still possible (though not observationally supported as of today) that it might eventually reverse sign and cause a collapse.

Check Your Progress IV

Note: Use the space provided for your answers.

1) Give an evaluation of the cyclic theory of the universe?

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2) What is a false vacuum?

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4.4 LET US SUM UP

In this unit after having seen some of the theories on the origin of the universe, we have focussed on the end of the universe. The whole unit has been dealing with the different scientific theories and not the religious theories of the origin and destiny of our universe.

4.5 KEY WORDS

Singularities : Singularities are zones which defy our current understanding of physics. They are thought to exist at the core of "black holes." Black holes are areas of intense gravitational pressure. The pressure is thought to be so intense that finite matter is actually squished into infinite density (a mathematical concept which truly boggles the mind). These zones of infinite density are called "singularities."

Big Crunch : In physical cosmology, the Big Crunch is one possible scenario for the ultimate fate of the universe, in which the metric expansion of space eventually reverses and the universe recollapses, ultimately ending as a black hole singularity.

Big Rip : The Big Rip is a cosmological hypothesis first published in 2003, about the ultimate fate of the universe, in which the matter of the universe, from stars and galaxies to atoms and subatomic particles, are progressively torn apart by the expansion of the universe at a certain time in the future.

The Big Bounce : The Big Bounce is a theorized scientific model related to the formation of the known Universe. It derives from the cyclic model or oscillatory universe interpretation of the Big Bang where the first cosmological event was the result of the collapse of a previous universe

Big Freeze : Recent observations suggest that the expansion of the universe will continue forever. If so, the universe will cool as it expands, eventually

becoming too cold to sustain life. For this reason, this future scenario is popularly called the Big Freeze.

Heat Death and Cold Death: In a simple definition, heat death will occur when all energy (heat) is supposedly evenly distributed throughout the universe, so that there is no place for it to go. In thermodynamics, energy is continuously being transferred through objects in the form of work or heat. The heat-death of the universe is when the universe has reached a state of maximum entropy. This happens when all available energy (such as from a hot source) has moved to places of less energy (such as a colder source). Once this has happened, no more work can be extracted from the universe. Since heat ceases to flow, no more work can be acquired from heat transfer. This same kind of equilibrium state will also happen with all other forms of energy (mechanical, electrical, etc.). Since no more work can be extracted from the universe at that point, it is effectively dead, especially for the purposes of humankind. This concept is quite different from what is commonly referred to as cold death. Cold death is when the universe continues to expand forever. Because of this expansion, the universe continues to cool down. Eventually, the universe will be too cold to support any life; it will end in a whimper. The opposite of cold death, is NOT "heat death" but actually the Big Crunch. The big crunch occurs when the universe has enough matter density to contract back on itself, eventually shrinking to a point. This shrinking will cause the temperature to rise, resulting in a very hot end of the universe.

4.6 FURTHER READINGS AND REFERENCES

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Student Satisfaction Survey

Student Satisfaction Survey of IGNOU Students

Enrollment No.	
Mobile No.	
Name	
Programme of Study	
Year of Enrolment	
Age Group	☐ Below 30 ☐ 31-40 ☐ 41-50 ☐ 51 and above
Gender	☐ Male ☐ Female
Regional Centre	
States	
Study Center Code	

Please indicate how much you are satisfied or dissatisfied with the following statements

Sl. No.	Questions	Very Satisfied	Satisfied	Average	Dissati-sfied	Very Dissati-sfied
1.	Concepts are clearly explained in the printed learning material	☐	☐	☐	☐	☐
2.	The learning materials were received in time	☐	☐	☐	☐	☐
3.	Supplementary study materials (like video/audio) available	☐	☐	☐	☐	☐
4.	Academic counselors explain the concepts clearly	☐	☐	☐	☐	☐
5.	The counseling sessions were interactive	☐	☐	☐	☐	☐
6.	Changes in the counseling schedule were communicated to you on time	☐	☐	☐	☐	☐
7.	Examination procedures were clearly given to you	☐	☐	☐	☐	☐
8.	Personnel in the study centers are helpful	☐	☐	☐	☐	☐
9.	Academic counseling sessions are well organized	☐	☐	☐	☐	☐
10.	Studying the programme/course provide the knowledge of the subject	☐	☐	☐	☐	☐
11.	Assignments are returned in time	☐	☐	☐	☐	☐
12.	Feedbacks on the assignments helped in clarifying the concepts	☐	☐	☐	☐	☐
13.	Project proposals are clearly marked and discussed	☐	☐	☐	☐	☐
14.	Results and grade card of the examination were provided on time	☐	☐	☐	☐	☐
15.	Overall, I am satisfied with the programme	☐	☐	☐	☐	☐
16.	Guidance from the programme coordinator and teachers from the school	☐	☐	☐	☐	☐

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