# UNIT 1 SPACE AND TIME

**Contents**



## 1.0 OBJECTIVES

This unit takes the students to the speculative, philosophical and scientific notions of space and time.

## 1.1 INTRODUCTION

Space and Time remain as one of the riddles in philosophy since ancient period. Are space and time ultimately real? Or they are real only with reference to phenomena or event is still a debatable question. Those who support the absolute theory of space and time argue that space and time are ultimately real. But those who disagree with the absolute existence of space and time argue that space and time are real only with reference to phenomena. Space and time are non-existent if they are divorced from events. Space and time act as receptacle of events. Events are meaningless without spatio-temporal characteristics. They are also thinkers who support the theory that space and time are 'empty.' Are space and time finite or infinite? There is no 'beginning' and 'end' for space and time accounting to the infinite theory of space and time. There is also no 'direction' for space and time. We do not know where is the starting point for this cosmos nor do we know the terminus of it.

## 1.2 PERCEPTUAL AND CONCEPTUAL SPACE AND TIME

When we perceive the external world we see in front of us the perceptual world. When we slowly turn our heads, the 'horizon' of the perceptual world changes and there is continuity in our perception. 'Far,' 'near,' 'above,' 'below,' 'by the side of,' 'under' etc. are some of the words we use to refer to the spatial quality of our perception. Perceptual space is 'sensibly continuous.' Perceptual time is the experience of an event when it 'endures.' The duration of the event is a continuation of the past to the present and the future. Perceptual space and time are experienced by us through events. Perceptual space is finite. It can be divided into smaller units.

The divided segments of the infinite space can be quantitatively measured. Perceptual space has got directions and reversible.

But perceptual time is irreversible. It can be divided into smaller units. Both percpetual space and time are limited and can be specified to particular contexts or phenomena. Conceptual space and time are infinite, unlimited, and abstract and has no directions. They are indivisible and imagined. It is possible to go to the present from the past or from the past to the present. Conceptual space is infitite in the sense that our imagination cannot limit the space. The mind can form an idea about small or big space. Once can also imagine future time. Since the space or time which are imagined are called conceptual space or time, they are not limited.
There are other theories of space and time too apart from the perceptual and conceptual theories of space and time.

1) Idealistic theory of space and time (Kant)
2) Realistic theory of space and time (Samuel Alexander)
3) Anti-Intellectualistic theory of space and time (William James and Henri Bergson)
4) Realitivistic theory of space and time (Albert Einstein)

## 1.3 IDEALISTIC THEORY OF SPACE AND TIME

Immanuel Kant is the exponent of Idealistic theory of space and time. His views on space and time are discussed in his *The Critique of Pure Reason.* According to him our perception (which he calls '*phenomenon'*) consists of two parts: that due to object, which he calls 'sensation,' and that due to our subjective apparatus, which, he says, causes the manifold to be ordered in certain relations. This latter part he calls the form of the phenomenon. This part is not itself sensation, and therefore not dependent upon the accident of environment; it is always the same, since we carry it about with us, and it is *a priori* in the sense that it is not dependent upon experience. A pure form of sensibility is called a 'pure intutition'; there are two such forms namely spasce and time, one for the outer sense, one for the inner. As pure forms of intuition the mind projects spatio-temporal characteristics to the objects of perception. Therefore the external objects themselves do not have space and time. They are the subjective (as forms of intuition) projections of the inner mind. Idealistic view of Kant with regard to space and time are established by him by using antinomicial concepts. Antinomical concepts are opposite concepts. In case space and time are not subjective, but objective, it is inevitable that the following possibilities will exist simultaneously:

1) That space and time are both finite and infinite
2) That space and time are both divisible and indivisible
3) That space and time are both part and whole

If space and time are assumed to be objective, realistic or empirical, the above possibilities will exist simultaneously. It is non-sensical to say that space and time are finite and infinite divisible and indivisible, and part and whole simultaneously. Therefore according, to Kant to overcome this problem it is necessary to say that space and time are Idealistic. The antinomical (opposite) concepts such as finite-infinite, divisible-indivisible, part-whole are used by Kant to prove his Idealistic theory of space and time. Kant also uses tow classes of arguments to prove that space and time are *a priori* forms of intuition: (1) metaphysical and (2) epistemological (which he calls transcendental). The metaphysical arguments are taken directly from the nature of space and time and the transcendental arguments are taken indirectly from the possibility of pure mathematics. As regards space metaphysical arguments are four in number:

1) Space is not an empirical concept, abstracted from outer experiences, for space is presupposed in referring sensations to something external, and external experience is only possible through the presentation of space.

2) Space is a necessary presentation *a priori*, which underlies all external perceptions; for we can not imagine that there should be no space, although we can imagine that there should be nothing in space.

3) Space is not a discursive or general concept of the relations of things in general, for there is only one space, of which we call 'spaces' are parts, not instances.

4) Space is presented as an infinite given magnitude, which holds within itself all the parts of space; this relation is different from that of a concept to its instances and therefore space is not a concept.

The transcendental argument concerning space is derived from geometry. Kant holds that Euclidean geometry is known *a priori,* although it is synthetic, i.e., not deducible form logic alone. Geometrical proofs depend upon the figures. The objects of sense must obey geometry, because geometry is concerned with our ways of perceiving, and therefore we can not perceive otherwise. This explains why geometry, through synthetic, is *apriori* and *apodeitic.* The arguments with regard to time are essentially the same, except that arithmetic replaces geometry with the contention that counting takes time.

## 1.4 REALISTIC THEORY OF SPACE AND TIME

Samuel Alexander is the exponent of the realistic theory of space and time. The basic elements of Alexander's system can be traced to the great philosophers of the past, and the scientific thinkers of his time but his greatness lies in synthesizing them into an original form all his own. Like Lloyd Morgan, Alexander was a naturalist and an empiricist. But whereas Morgan starts from physical events related in space and time and tries to show how, out of these, all inorganic material substance, life and mind can be conceived to emerge, Alexander pushes the idea of emergence still further and shows how the entire universe including all physical events, life, mind and even deity can be conceived to evolve out of Space-Time emerges out of the matrix of Space-Time. Space-Time is the basic of a 'Pyramid' structure of emergent evolution and out of it emerges the higher levels, matter, life, mind and deity. Deity forms the apex of the pyramid, and there is *anisus* toward the deity inherent in the process of evolution. This explains the upward direction of the process. For Alexander epistemology is not the necessary preliminary to metaphysics and mind is a natural phenomenon. Every experience may be analysed into two district elements and their relation to one another. The two elements which are the terms of the relation are, on the one hand the act of mind or the awareness and on the other the object of which it is aware; the relation between them is that they are together or compresent in the world which is thus so far experienced. I am aware of my awareness and my awareness and my being aware of it are identical. But I am aware of an object, as something distinct from awareness and present before it. To keep the distinction between subjective and objective knowledge clear, Alexander calls the former enjoyment, and the latter contemplation. The mind enjoys itself; but the mind contemplates a true (in perception), an image (in memory) etc. While for Berkeley 'reality is ideas,' for Alexander 'ideas are reality.' Since he keeps the identity between the object contemplated and the object existing he is an epistemological monist or a neo-realist.

## 1.5 SPACE-TIME: THE ULTIMATE STUFF OR MATRIX

Space-Time, conceived as 'a system of motion' is hypothetically posited by Alexander as the stuff or matrix (or matrices) out of which things or events emerge. All finite beings are in some sense complexes of space and time. His procedure is not deductive, but, like that of science, empirical. He starts with the hypothesis of space-time and shows gradually that it can account for all observable phenomena, and thus the hypothesis becomes verified and justified. Unlike Spinoza and Kant, for Alexander space and time are inseparable system of motion. In this regard he agrees with Einstein's space-time continuum. Our experience of the finite space and time are parts of the imagined space and time. Therefore there is no reason to say that infinite space and time are unreal. Space and Time are ordinarily regarded as separate and independent. But their separation is the result of abstraction. For Alexander space and time are interdependent so that there neither is space without Time nor Time without space; that space is in its very nature temporal and Time spatial. Time, apart from space, would be nothing more than a mere succession of discrete instants, and there would be nothing to unite these discrete members into a continuous whole. If, therefore, the past instant is not to be lost as it otherwise would be, or rather since this is not the case in fact, there needs must be some continuum other than Time which can secure and sustain the togetherness of past and present, of earlier and later. This other form of being is space; that is space supplies us with the second continuum needed to save Time from being a mere 'now.' As Time in so far as it was temporal became a mere 'now,' so space as merely spatial becomes a blank. It would be without distinguishable elements. But a continuum without elements is not a continuum at all. Time distinguishes and separates the parts of space. Thus Space and Time depend each upon the other. Without space there would be no connection in Time. Without Time there would be no points to connect. There are no such things as points or instants by themselves. There are only point-instants or pure events. In fact there is no instant of time without a position in space and no point of space without an instant of time. A point occurs at an instant and an instant occupies a point. We can not think of the existence of a portionof space without thinking of it as existing at a particular date or time; and similarly we can not think of a particular time without thinking of it as the time of objects existing in space. Ideas of space and time are, therefore, mutually interdependent. Space-Time presents a very complex system which can be grasped by the idea of motion. Even a particle and its motion is a made of Space-Time, Mind is made of Space-Time. Mental acts are really identical with neural processes, so that awareness of enjoyment of an act of mind is nothing but the enjoyment of a neural process with its own time and space. Therefore mind also is made of the stuff of Space-Time.

## 1.6 CATEGORIES, QUALITIES AND VALUES

Space-Time matrix gives rise to all existents by its internal differentiation. All objects have two different kinds of characters, pervasive and variable. The pervasive characters follow from the spatio-temporal nature common to all objects. These are called categories. The variable characters are those which are generated by special kinds of grouping of Space-Time and are found in special classes of existents. These are called qualities. The categories are the essential and universal constituents of whatever is experienced and they are common to the mental and non-mental. They are *a priori,* whereas qualities are empirical. The categories are *a priori,* not in the sense that they are not experienced; but in the sense of being pervasive and universal like the a priori categories of Kant. Alexander gives the natures of the different groups of categories such as; (1) Identity, diversity and existence (2) Universal, particular and individual (3)relation (4) order (5) substance, causality, reciprocity (6) quantity and intensity (7) whole and parts and number (8) motion. These categories are derived from the different aspects of the Space-Time system. Space-Time relationship is analogous to mind-body relationship. As the mind intitiates, guides and organizes the activities of the body, so also does Time with regard to space. The first thing to emerge out of space-time (or motion) by the activity of Time on space is finite motion. By a further grouping and complexity there emerges the next quality: Matter with primary qualities. Similarly in the course of further complexities and motions, the qualities such as matter with secondary qualities, life, mind and deity emerge. According to Alexander even deity is a product of emergent evolution from Space-Time (motion). For Bergson *Elan Vital* or reality pushes from behind the species and therefore evolution is creative. But deity according to Alexander is neither transcendental nor a force pushing from behind as the cause of evolution. Just like matter life and mind even deity is a product or quality emerging out of Space-Time matrix. However it must be admitted that Deity is the finest quality to be evolved from Space-Time.

As far Alexander's realistic conception of Space and Time, it must be stated that Space and Time have independent existence of their own. For Kant, Space and Time have no objective or independent existence. They are subjective or *a priori* forms of intuition. Such an idealistic view of space and time is refuted by Samuel Alexander by accepting space and time to be objectively real. On the contrary even the mind is a by product of Space-Time matrix. The values such as truth, goodness and beauty though dependent on mind are not the qualities of Reality. They are the products of interaction between mind and Reality. They arise out of mind's interpretation, utilization and appreciation, or in a word valuation of Reality. They should be called, therefore, values rather than qualities (of Reality). Reality in itself is neither true, nor, good nor beautiful. What is more important to remember here is that even values are product of Space-Time.

## 1.7 ANTI-INTELLECTUALISTIC INTERPRETATION OF SPACE AND TIME

The anti-intellectualistic trend in philosophy was advocated by philosophers like William James and Henri Bergson. Their attitudes revolted against Absolute Idealism. The study of Biology left a permanent impression on Bergson, and moulded his metaphysical outlook. While the materialist tries to interpret the whole world-matter, life and mind-in terms of matter alone, and the idealist in terms of mind alone, Bergson attempts to understand everything in terms of life. The fundamental idea of Bergson's thought is the life-force which we feel throbbing within us. The world of matter lying extended before us and ideas appearing within our mind are understood as products of the same life-impetus which Bergson calls as *Elan Vital.* The vital force, *elan vital,* is in a flux or change. Due to change there is evolution which is creative. Man, plants and animals are the three dimensional changes brought about by the vital impetus. The metaphysics of Bergson is based on the philosophy of change. His philosophy of change is based on his philosophy of time. He calls time as *duree* (duration). Time is popularly understood as the succession of homogeneous moments which do not differ from one another in respect of character of quality. Motion, too is conceived, according to this idea of time, as the occupation of different positions in space at successive instants of time and it becomes thus a source of endless puzzles and paradoxes as Zero points out. This popular conception of time is mechanical and mathematical which is static. Bergson does not agree with the mathematical and mechanical conception of time. According to him time is duration, *duree,* which is the basis for all changes or for events to take place. Events take place in time in the internal world as well as in the external world. The states of consciousness succeed one another in our mind and things which are perceived are simultaneous, extended in space, outside one another. They are present all together. There is thus neither past nor future in space, and therefore, no succession. The external world is the simultaneous togetherness of many objects existing side by side. The so called successive states of the external world are nothing but different simultaneous presentations of the world arranged successively by the mind. If we deduct mental activity there would be nothing left but simultaneity and the external world would be devoid of time or succession. There are two aspects of our mental life a superficial one, and a deeper one. In its superficial aspect it consists of sensations, emotion, thoughts etc., which are separated, isolated, named and arranged one after another. Succession belongs only to this superficial aspect. But in its deeper aspect the different experiences of the mind are inseparably intermingled, they interpenetrate and form one concrete whole, in which no element is outside another and the elements, are not, therefore, arranged in any order of succession. In every intense experience we have an undistinquished multiplicity of elements blending into a moving whole whose intensity is due to the cumulative force of the interpenetrating elements. If we accept the view that time can be measured like space, the most fatal consequence of spatialisation, is that we come to believe that the past is left behind, and is dead and gone, and the future lies ahead and therefore the present is all that is left, and is of any consequence. But for Bergson real time is an unbroken concrete unity or whole which are not abstract or independent units. The spatialised and abstract conception of time can not grasp the Reality which is unceasing action or change. Motion or change can be understood only through a time which is dynamic and not static. There must be something continuing and developing through the different states to unify them into one process of change, or rather there would be only a discrete and discontinuous multiplicity. Therefore for Bergson time does not mean succession, and change does not mean mere succession of states – the replacement of one state by another. But time is duration which is the nature of real change itself. "Duration is the continuous progress of the past which gnaws into the future and which swells as it advances. And as the past grows without ceasing, so also there is no limit to its presentation." Every present experience is felt as duration. It is as James says, like a 'saddle back,' and not like a 'needle point' or a 'knife edge.' The past, present and future interpenetrate into a dynamic whole which is analysed by the intellect into successive static ideas. The different aspects of Bergson's philosophy centre round this conception of Time or change. Time, change and consciousness are related to each other. Bergson tries to show through his philosophy the dialectical nature of *Elan Vital* by using the opposites such as matter-memory, space-time, intellect-intuition, closed morality-open morality and static religion-dynamic religion. The forward movement of *Elan Vital* overcomes the obstacles created by matter, space, intellect, closed morality and static religion.

## 1.8 RELATIVISTIC THEORY OF SPACE AND TIME

The classical physics of Newton was not challenged by the scientists till the beginning of the 20th century. However some of the new discoveries in science during the 20th century could not be explained by the Newtonian concepts adequately. The Newtonian mechanics and his absolute theory of space and time were criticised by scientists like Albert Einstein. Newtonian theory of classical mechanics considered the ether as the medium of motion and space. Time and motion were independent of each other. The three dimensional space and one dimensional time were separable with each other. The invention of electro magnetic field, sub atomic particles and quantum mechanics challenged the Newtonian classical mechanics. Newton's proofs of absolute space were proved to be fallacious by the modern science. His first proof that absolute motion proves absolute space and the former is proved by force, is a vicious circle, for the forces are only postulated to explain motion. His second proof is derived from circular motion such as what produces the concavity of the surface of a rotating pail of water, but this is now thought to be due not to empty space but to them matter filling it. Newton's third proof that relative motions are differences of absolute ones is not tenable for an absolute motion or translation of a body from one part of absolute space to another cannot be known because these parts are indistinguishable. A body can move not with reference to absolute space but to other bodies. The ideas of absolute space were finally abandoned after the experiments of Michelson-Morley who did not find any difference in the velocity of light when measured once in the direction of and then perpendicular to earth's movement. Such a difference ought to have there if light were electromagnetic vibrations in a medium, called ether, pervading all space. By absolute space Newton understood the empty and motionless space of the universe. He used the term 'absolute' to characterise the invariance of lengths and time intervals. In classical mechanics the concept of absolute time found its expression in the recognition of absolute simultaneity; if any two events occurred simultaneously in one inertial system of reference, they were also found to occur simultaneously in another. The conclusion ensuing from the principle of the constancy of velocity of light was entirely different: Two events which took place simultaneously in one system of reference could not be simultaneous in another. In other words, simultaneity according to this principle is relative.

## 1.9 EINSTEIN'S RELATIVITY THEORY

To overcome the difficulties faced by the scientists due to Newton's absolute theory of space and time, Einstein gave his historical theory of Relativity. Einstein did not agree with Newtonian conception of the independent existence of space, time and motion. For him all three are interdependent to each other. It is space-time and not space and time. In other words space-time continuum with energy (matter) was well received by the world of science. According to Einstein the position of the observer and the gravitational force play an important role in the relativity of the units of measurement in science. For example if one's weight is 60 kg. on earth, his weight on the moon will be only 12 kg., since the gravitational force of moon is only $1/5^{th}$ of that of earth. Hence the weight of an individual is relative to his position (with reference to particular location and time). Position of the observer as 'relative' factor is discussed in Einstein's *Special Theory of Relativity.* His *General Theory of Relativity* discusses the influence of gravitation as a factor of relativity in science. There are no simultaneities in the occurrence of events since the time of occurrence of an event and the time of observation of the same are not simultaneous. The stars we see on the sky would be the effect of the light caused by the stars during the period of Emperor Asoka. The light would have taken more than two thousand years to reach our eyes yesterday. Therefore our observation of celestial phenomena is misleading if we assume that there is simultaneity of the occurrence of an event and our observation of the same. Moreover there is bending of light due to gravitation and therefore the location of the star we observe is shifted to some other place.

Gravitation influences not only space but also time. The velocity of light will change depending upon the gravitational pulls of the celestial bodies. The velocity of the spin of earth and the distance between stars and planets are not absolute. We take for granted that these measured units will not change. What we measure in everyday life is relative to so many other factors mentioned above. Euclids' geometry is also not acceptable to Einstein. According to Euclid the sum of the three angles of a triangle must be 180 degree. But if this rule is applied to Matter and Motion, it is not correct. The classical physics of Newton and the assumption that matter should occupy space has been disproved by the modern interpretation of matter as 'energy.' Einstein's theory of relativity showed variant character of space and time. It is correct in the sense that the theory revealed new links and relationships which had not been taken into account by classical physics and thus gave a broader and more profound picture of the dialectics of time-space relations.

## 1.10 INFINITY OF SPACE AND TIME

Can we fix the starting point or beginning and the terminus for space and time? We can be conscious of space and time as long as we live. Does it mean that there was no space and time before our births and there will be no space and time after our deaths? If we travel upwards can we reach the end of the sky? These are some of the perplexing questions which evoke curiosity in the human mind. There are millions of galaxies in the universe. The Milky Way, our galaxy is only a fraction of the whole universe. Therefore we are not at the centre of the universe. We don't know the beginning and the end of this vast universe. Space and time have no privileged axis. There is no arrow of time so that we can indicate the direction of the movement of our galaxy. Milky way is one the connecting chains of the continuity of the universe. The cosmic phenomena involving infinite quantities of matter and space are still a mystery. Man is completely lost in the infinity of space and time.

## 1.11 LET US SUM UP

We have given representation of different traditions of human thought and discovery on reality of space and time.

## 1.12 KEY WORDS

**General Theory of Relativity** discusses the influence of gravitation as a factor of relativity in science.

## 1.13 FURTHER READINGS AND REFERENCES


Heller, M, Woodin WH. *Infinity: New Research Frontiers*. Cambridge: Cambridge University Press, 2011.

Engelbert, P. *Astronomy & Space: From the Big Bang to the Big Crunch*. Detroit: UXL, 1997.

Riniolo, Todd C and Lee Nisbet. "The Myth of Consistent Skepticism – The Cautionary Case of Albert Einstein." *Sceptical Inquirer.* May/June 2007. 49-53.

Armstrong, D. *What is a Law of Nature?* Cambridge: Cambridge University Press, 1983.

## UNIT 2 EXPANDING UNIVERSE



**Contents**



## 2.0 OBJECTIVES

- To study the expanding universe.
- To see how expanding universe has given rise to the contemporary cosmological theories.
- To a brief idea of the nature, history and end of the universe.

## 2.1 INTRODUCTION

In this unit, we explore the phenomenon of expanding universe and see how it has given rise to the scientist cosmology of today. The unit is written depending heavily on the scholarly and reader-friendly article of an American Physicist, Gary Felder (2000).

## 2.2 THE PHENOMENON OF EXPANDING UNIVERSE

One of the features of the Big Bang cosmological model is an expanding universe. That is, starting from a very hot and very dense singularity, the components that evolved into what is now our universe first experienced a cataclysmic event. What followed was a continuous expansion, cooling, and thinning out of these components. The idea that the Universe is expanding has far-reaching ramifications in the field of physics than simply being another amazing astronomical phenomena. For one, it allows for a unification between those who have spent their lives studying the very small (particle physicists) and those who have dedicated theirs with the very large (astrophysicists). For a long time, particle physicists toiled in the middle of a particle zoo. The discoveries of quarks, leptons, as well as the strong, electromagnetic, weak, and gravitational forces filled their labs with mixed feelings (Villanueva 2009).

On one hand, they were constantly excited with the wealth of discoveries of these numerous tiny particles and their interactions, while on the other, they were conscious of the fact that the diversity of these forces deviated from the idea that nature was biased towards simplicity. They realized these forces should eventually unite for simplicity to prevail. From their calculations, this was only possible in the presence of very high energies. But since these energies were not present anywhere in the Universe, then the possibility was useless. This puzzle was solved when scientists studying cosmology realized that the Universe was expanding and as a result, was cooling and becoming less dense (Villanueva 2009 and Hawking 2002).

Scientists analyzed that if this were true, then it could be possible that the Universe was once very hot and very dense. In these conditions, the energies would have been extremely high.

There are proofs that the Universe experienced a cataclysmic event (Big Bang) and, subsequently, that it is expanding even now. One of the proofs is the detection of the cosmic microwave background radiation exhibiting a thermal black body spectrum of about 3 K. Another is the collection of red shift observations for galaxies, i.e., the further from us the galaxies are, the greater their measured red-shifts. That means, the outermost galaxies are speeding away much faster than the innermost ones. These two alone support the Big Bang theory (Villanueva 2009).

## 2.3 HISTORICAL BEGINNINGS

In 1929 an astronomer named Edwin Hubble announced a remarkable observation that changed our view of the world more than almost any other single discovery made this century. In every direction he looked, every galaxy in the sky was moving away from us. The nearby ones were moving relatively slowly, but the farther away a galaxy was the faster it was heading out. What can account for our great unpopularity? Is our galaxy somehow different from all others?

It turns out that there is another, arguably simpler explanation that is well supported by many other observations. It is that the entire universe itself is expanding! This expansion indicates not only that we should see every other galaxy moving away from us, but that observers in another galaxy should see exactly the same thing. In a uniform expanding universe, every observer sees herself at the center of the expansion, with everything else moving outwards from her (Felder 2000).

This statement forms the basis of our current theories of the structure and history of the universe. The study of the overall structure of the universe is called cosmology. The theory that has come to dominate cosmology since Hubble's observations goes by several names, but is most commonly known as the *big bang model.* This rest of this unit describes the big bang model. Next section describes what it means to say the universe is expanding, and subsequent sections address some questions that commonly arise in connection with the model.

Then the  following Section discuss whether the universe is infinite or finite. While we don't yet know the answer to this question, Einstein's general theory of relativity predicts that finite universes contain a larger density of matter than infinite ones, so by measuring the density in the universe we should hopefully be able to make the determination. We end section by describing what it would mean for the universe to be infinite or finite (Felder 2000 and Brown 2007).

In the next Section we talk about the origin and history of the universe. As the universe expands and galaxies move apart from each other the average density is decreasing (Brown 2007). If we extrapolate the expansion backwards we conclude that there was a time roughly 10-15 billion years ago when the density was nearly infinite. In this section we briefly outline the history of the universe from that time to the present. In the final Section we continue the story, describing what relativity theory predicts will happen to the universe in the future. The two possibilities are that the universe will continue to expand forever or that it will eventually slow down and begin contracting. The theory tells us that which one will happen depends on whether or not the average density of the universe exceeds a certain value, the same value that determines whether the universe is infinite or finite. Relativity predicts that an infinite universe will continue to expand forever, whereas a finite universe will expand for a finite time and then contract (Russell 2009 and Felder 2000).

**Check Your Progress I**

**Note**: Use the space provided for your answers.

1) What are some of the proofs for Big Bang?

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2) What is the big bang model?

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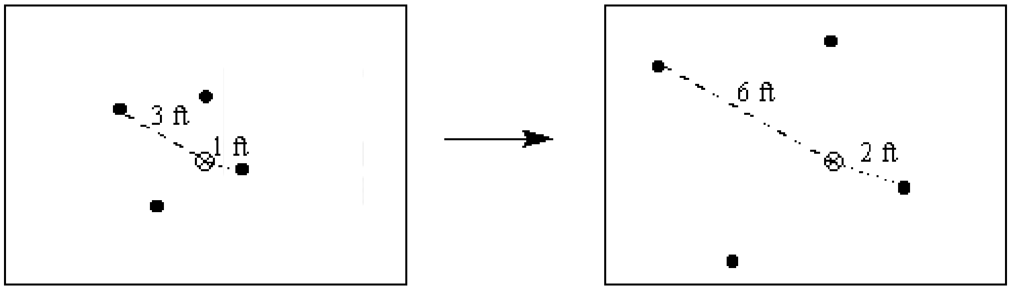
## 2.4 THE EXPANDING UNIVERSE: AN OVERVIEW

Simple analogies can clarify what it means for the universe to expand, but they can also be misleading. We can use one analogy, attempting to point out its shortcomings as we proceed. Think of the universe as a rubber sheet being stretched out. (If you are comfortable with visualization in three dimensions you can imagine a raisin cake expanding instead, but for the purpose of illustration we will stick with the two dimensional case.) Now imagine that there are drawing pins stuck into the rubber at various points representing galaxies. (In the raisin cake analogy these would be the raisins.) As the rubber (the universe) is stretched (expands), the drawing pins (galaxies) all get farther apart. Note that we haven't said anything yet about how big the rubber sheet is. For all we know it might be infinite. (This point will be addressed in a later section.) What we mean when we talk about expansion is that the rubber is being stretched out, causing the distances between the drawing pins to increase (Felder 2000 and Brown 2007).

To see what this expansion should look like to us, imagine an observer sitting on one of the drawing pins. This observer imagines himself to be at rest and measures all movement relative to his drawing pin (galaxy). Since the distance between any two drawing pins is increasing, it will appear to him that all the other ones are moving away from him. How fast will another drawing pin appear to move? That depends in part on how fast the rubber sheet is being stretched out, *i.e.*, how fast the universe is expanding. In addition, however, the apparent speed of the other drawing pins is also dependent on their positions relative to the observer. The nearby drawing pins will appear to be moving away very slowly, whereas the distant ones will appear to be moving away much faster. To see why this is so, suppose the rubber sheet doubles in size in one second.




The drawing pin that began one foot away from you is two feet away, meaning it appears to have moved by a foot. Its apparent velocity is therefore 1 foot per second. In the same time the drawing pin that started out three feet away also ends up twice as far away (six feet), but this means that it appears to have moved away at three times the speed of the first drawing pin (three feet per second). In terms of the expanding universe, this means that not only will every galaxy appear to be moving away from us, but the speed with which it does so will be directly proportional to its distance from us. A galaxy that is four million light years away will have twice the apparent velocity of one that is two million light years away (Felder 2000).

This pattern is precisely what Hubble observed. Not only did he see that all distant galaxies are moving away from us and that the more distant ones are moving away more rapidly, but he found that the rate at which they were receding from us was proportional to their distance from us (Felder 2000). In other words, his observations exactly matched what we just predicted for an expanding universe. This proportionality is known as Hubble's Law.

A problem arises when we consider an expanding universe. Suppose everything in the universe were to double in size. The distances between galaxies would double, the size of the Earth would double, the size of all our meter sticks would double, and so on. It would seem to an observer (who will also have doubled in size) as if nothing had happened at all. So what do we mean by saying the universe expands?

In fact, not everything grows as the universe expands. In the example of the rubber sheet, the distance between drawing pins keeps increasing but the drawing pins themselves remain the same size. Similarly, while distant galaxies are pulled away from each other by the expansion, smaller objects like meter sticks, people, and the galaxies themselves are held together by forces that prevent them from expanding. So we expect that billions of years from now galaxies will still be roughly the same size they are today, but the distances between them will on average be much larger.

## 2.5 INFINITE OR FINITE?

People have wondered for millennia whether the universe is limited in size or goes on forever. Fortunately we now have modern science to step in and supply us with the answer, which is that we don't know. We believe that the universe is governed by Einstein's theory of general relativity, which among other things addresses such matters as the overall structure of the universe. In the early 1920s Alexander Friedmann showed that using one assumption the equations of general relativity can be solved to show that a finite universe must have a larger density of matter and energy inside it than an infinite universe would have (Felder 2000). There is a certain *critical density* that determines the overall structure of the universe. If the density of the universe is lower than this value, the universe must be infinite, whereas a greater density would indicate a finite universe. These two cases are referred to as an *open* and *closed* universe respectively. The critical density is about $10^{-29}$ g/cm$^3$, which is equivalent to about five hydrogen atoms per cubic meter (Felder 2000). This may not seem like a lot; by comparison the density of water is roughly 1 g/cm$^3$ or about 500 billion billion billion hydrogen atoms per cubic meter. However, we live in a very dense part of the universe. Most of the universe is made up of intergalactic space, for which a density as low as the critical density is plausible.

Aside from the theory of relativity itself, Friedmann's only other assumption in deriving his results was that on average the density of the universe was the same everywhere. This doesn't mean that every place in the universe is exactly the same. We already mentioned that the Earth is much more dense than space. However, if we measure the average density in our galaxy it will be about the same as the average density in any other galaxy, and the number of galaxies per unit volume should be roughly the same in different parts of the universe. This assumption matches all our observations to date. Individual galaxies differ from one another in some of their specific properties, but on average their properties don't appear to change from one region of the sky to another. Nonetheless, the idea that the universe is roughly the same everywhere—a property known as *homogeneity*—is still an assumption. We can probably only see a tiny fraction of the universe and we have no guarantee that the parts we cannot see look like the parts we can. Lacking any evidence to the contrary, however, we will assume that the property of homogeneity holds true.

So we should be able to answer the question of the universe being infinite or finite by measuring the density of everything around us and seeing whether it is above or below the critical value. This is true in principle, and measuring the average density of the universe is a very active field of research right now. The problem is that the measured density turns out to be pretty close to the critical density. Right now the evidence seems to favor an infinite universe, but it is not yet conclusive.

To recap, one of the assumptions of the standard big bang model is that the universe is more or less homogeneous—the same everywhere. As far as we can see, which is billions of light years in every direction, this assumption appears to be correct. Under this assumption general relativity says that whether the universe is infinite or finite depends on its density. Measurements of that density reveal that it is close to the critical value. Right now the data seem to point more towards an open (infinite) universe, but new data coming in the next 10-20 years should resolve the question much more definitively (Felder 2000).

Given our uncertainty about this question, we will briefly comment on what it would mean if the universe is infinite or finite and how those two possibilities relate to the idea of the universe expanding. An infinite universe is in some ways easier to imagine than a finite one. Since the universe is supposed to be everything that exists, it seems intuitive that it should go on forever. Of course an infinite universe is impossible to picture, but we can get at what it means by saying that no matter how far you go there will always be more space and galaxies. It is hard, however, to reconcile this picture with the idea that the universe is expanding. If it's already infinite, how can it expand?

To see how, remember that by expansion we mean that the distance between galaxies is increasing. Suppose right now there is a galaxy every million light years or so. After a long enough time this infinite grid of galaxies will stretch out so that there is a galaxy every two million light years. The total size of the universe hasn't changed—it's still infinite—but the volume of space containing any particular group of galaxies has grown because the separation between the galaxies is now larger.

What about a finite universe? This phrase sounds like a contradiction because if the universe ends somewhere then we would naturally want to know what was beyond it, and since the universe includes everything, whatever is beyond that edge should still be called part of the universe. The resolution of this paradox is that even if the universe is finite, it still doesn't have an edge. If we head off in one direction and resolve to keep going until we find the end of the universe, we eventually find ourself right back where we started. A finite universe is *periodic*, meaning that if you go far enough in any direction you come back to where you started (Felder 2000).

Trying to picture a closed (finite) universe is in some ways even harder than trying to picture an open (infinite) universe because it is easy to mislead yourself. For example, people often compare a two-dimensional closed universe to the surface of a balloon. This analogy is helpful because such a surface has the property of being periodic in all directions, and it is easy to picture the expansion of such a universe by imagining the balloon being blown up. In fact, this analogy is like the rubber sheet analogy we used before, except now the sheet has been wrapped up to form a sphere. The problem is that this picture immediately leads to the question of what is inside the balloon.

This question comes from taking the analogy too literally. Nothing in general relativity says that a two-dimensional closed universe would have to exist as a sphere inside a three-dimensional space; the theory only says that such a universe would have certain properties (*e.g.* periodicity) in common with such a sphere. For this reason, as shown by Gary Felder (2000), it is useful to keep the balloon in mind as a convenient analogy but it is ultimately best to think of the closed universe as a three-dimensional space with the strange property that things which go off to the right eventually come back again from the left.

What does expansion mean in a closed universe? Since this universe has a finite size, it makes sense to talk about that size increasing. Again suppose that there is now a galaxy every million light years. Suppose also that if we were to head off in a straight line we would travel 100 billion light years before coming back to where I started, passing about 100,000 galaxies on the way. If we take the same journey billions of years later, the number of galaxies won't have changed but the distances between them will have doubled, so the total distance for the round trip will now be 200 billion light years.

**Check Your Progress II**

**Note**: Use the space provided for your answers.

1) What is the importance of Hubble’s Law?

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2) Is the universe finite?

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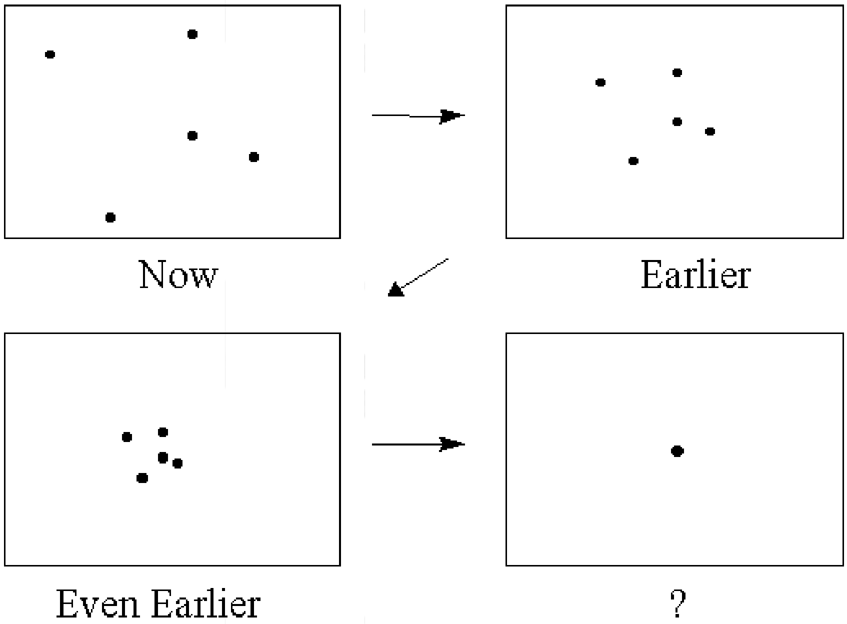
## 2.6 THE BIG BANG AND THE HISTORY OF THE UNIVERSE

At the beginning of this century, physicists generally had a strong bias toward the idea that the universe was essentially unchanging. Local phenomena would of course change from minute to minute, and stars and galaxies might be born and die, but taken as a whole the universe was assumed to be more or less the same now as it had been billions or trillions of years ago, with no beginning or end (Felder 2000). Einstein, disturbed that his theory of general relativity seemed to be inconsistent with a static universe, tried to modify the equations of the theory. When Hubble's observations showed that the universe was indeed expanding, Einstein retracted this modification and called it the biggest blunder of his life. Given that the universe is growing, the question of whether the expansion started at some point in the past inevitably arises. Our current theories say the expansion *did* have a beginning. This section discusses why we believe this and what it means to even say so. It also contains a brief outline of the history of the universe from that beginning to the present day.

### The Big Bang

To see what it means to say the universe had a beginning, consider a group of galaxies chosen at random throughout the universe. The illustration below shows five galaxies as they appear now and as they would have appeared at several times in the distant past. At some point in the past (about 6-10 billion years ago), all of these galaxies would have been half as far apart as they are now. At an earlier time they would have been half as far apart as that, and so on. If you extrapolate this process backwards you eventually come to a time in the past when the galaxies would have been right on top of one another. Put another way, the density of matter (or energy) in the universe was higher at earlier times, and extrapolating this process backwards we come eventually to a time when that density would have been infinite. This moment of infinite density is called the *big bang*.




Having defined the moment of the big bang in this way—the time when all distances between objects were zero— we cannot talk about that time. A point of infinite density, known in physics as a "singularity," makes no sense. Moreover, our current theories do not predict that such a moment occurred in the past. Our best physical theories, including general relativity and quantum mechanics, stop working when we try to describe matter that is almost infinitely dense. That word "almost" is important. The theories don't simply break down at the instant of the big bang singularity; rather, they break down a short time afterwards when the density has a certain value called the *Planck density* (Felder 2000).

The Planck density, which is the highest density we can hope to describe with our current physics, is over $10^{93}$ g/cm$^3$, which corresponds to roughly 100 billion galaxies squeezed into a space the size of an atomic nucleus. For virtually any application we can imagine this limitation of our theories is completely irrelevant, but it means we can't describe the universe immediately after the big bang. We can only say that our current model of the universe begins when the density was somewhere below the Planck density and we can say virtually nothing about what the universe was like before that. We therefore take as our initial condition a universe at or just below the Planck density, and any questions about the instant of the big bang itself are eliminated from consideration.

Is this a cop-out? It certainly is. Physicists have not given up on understanding what happened before this time, but we admit that right now we have no theory to describe it. Many people are working to develop such a theory, but until that happens we are left having to start our description of the universe when the density was large but still finite. Once we impose this limitation on ourselves, our picture of the universe works equally well for an infinite or a finite universe. If the universe is finite then it may very well have been extremely small at the moment when the density was at the Planck level. If the universe is infinite then it was also infinite at that early time. The density was enormous and the distances between particles vanishingly small, but that dense mass of particles went on forever.

**The History of the Universe**

Describing the history of the universe is obviously a fairly large task, so we can only with mentioning a few highlights. For a very good description of much of the early history the book *The First Three Minutes* by Steven Weinberg is excellent. At the moment when the density of matter equalled the Planck constant, the universe consisted of a hot soup of elementary particles. When we say this medium was hot that means that the particles, on average, had very high energies. All of the fundamental particles such as quarks, electrons, and photons were present. At present these particles are mostly combined into larger units such as atoms, molecules, penguins, and so on, but at the extremely high temperatures of the early universe they remained separate. If several particles were to have combined into a more complicated structure such as an atom they would have been instantly ripped apart in collisions with the high energy particles flying around everywhere. As the universe expanded, the density and temperature of this mixture decreased. After a small fraction of a second the quarks combined into protons and neutrons in a process called *baryogenesis.* A few minutes later the protons and neutrons combined into atomic nuclei in a process referred to as *nucleosynthesis.* Hundreds of thousands of years later these protons and neutrons combined with electrons to form atoms.

In the period of recombination the universe was still almost perfectly homogeneous, meaning that the density was the same everywhere. While the density still is the same everywhere when averaged over huge regions of space, it certainly varies locally. The density of the Earth is vastly larger than the density of interstellar space, which is in turn much greater than the density of intergalactic space. In contrast, the difference in density between the most and least dense regions at the time of recombination was about one part in 100,000. Between then and now the converging of matter into galaxies, stars, etc. took place (Felder 2000).

The mechanism by which this converging occurred is fairly simple, although its details continue to be studied and debated. At the time of recombination the universe consisted of a nearly uniform hot gas with regions very slightly denser than the average and others very slightly less dense. If the density had been *exactly* the same everywhere then it would have always stayed that way. However, a region slightly denser than the surrounding gas would have a stronger gravitational attraction, and mass would tend to flow into it. This process would make this region even denser, causing it to attract matter even more strongly. In this way the almost uniformly dense universe gradually became less and less uniform, resulting in the dense grouping of matter we see around us now. On a fairly large scale these groupings make up galaxies, and matter that grouped on a smaller scale makes up the stars inside those galaxies. A very small portion formed into smaller objects orbiting around those stars and a small portion of that matter formed into people reading physics papers on the Internet.

## 2.7 THE END OF THE UNIVERSE

Hubble's observation that the universe is expanding suggested more generally that the universe is changing with time. As in most subjects, we know more about the past than we do about the future, but if we assume that our current physical theories are correct then we can predict a great deal about the future of our universe. Is the universe going to exist forever or will it someday come to an end as it began? Put another way, will the expansion of the universe continue forever? If the universe keeps on expanding it will presumably continue to exist for an infinitely long time. On the other hand, if the expansion ever stops, then the universe will contract until it once again reaches the Planck density (and after that we have no idea what it will do). In what follows we will explain what determines which of these scenarios is going to occur and say more about what each of them means (Felder 2000).

We know from general relativity that expansion of the universe is slowed down by the mutual gravity of all the matter inside it. Whether or not the expansion will continue forever depends on whether or not there is enough matter in the universe to reverse it. If the density of matter in the universe is less than a certain critical value, then the universe will never stop expanding. If, on the other hand, the density of matter is greater than the critical value, then the pull of gravity will eventually be strong enough to stop the expansion and the universe will begin contracting. In Section III we saw that whether or not the universe is finite or infinite depends on whether the density of matter is above or below a critical value. That value turns out to be exactly the same as the critical value that determines whether or not the expansion will reverse. In other words, general relativity says that an open (infinite) universe will expand forever and a closed (finite) universe will eventually re-collapse.

If the universe expands forever, the clusters of galaxies in it will move farther and farther apart. Eventually each galaxy cluster will be alone in a vast empty space. The stars will burn out their fuel and collapse, leaving nothing but cold rocks behind. Eventually these will disintegrate as well. This whole process will take an unimaginably long time but it will occur eventually, and the universe will thereafter consist of nothing but loosely spread out elementary particles. All of the energy in the universe will then be distributed in a more or less uniform way at some extremely low temperature, and as the universe continues to expand this temperature will fall and the universe will become ever more empty and cold. This scenario is sometimes referred to as the heat death of the universe.

On the other hand, if the universe has a high enough density, then the galaxies will eventually start moving back towards each other. Once they are close enough together all galaxies and stars will collapse, until at some point the universe will once again consist of nothing but densely packed, highly energetic particles. Eventually all matter will be compressed to the Planck density, the density at which our current theories fail. Lacking a theory for such densities, we cannot predict what will happen then. One possibility is that the universe will bounce back—indeed, perhaps it has been in a cycle of expanding and contracting forever. Then again perhaps the universe will simply annihilate itself and cease to exist. Determining which of these possibilities would occur will require the development of a theory of physics at extremely high densities (Felder 2000).

**Check Your Progress III**

**Note**: Use the space provided for your answers.

1) Why did Einstein object to some of the elements of quantum mechanics?
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2) What is baryogenesis and what is its significance?

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## 2.8 LET US SUM UP

In this unit we discussed the expanding universe and some of the cosmological consequences that are derived from it. This gives rise to a world that is so gigantic and magnificient.

## 2.9 KEY WORDS

**Baryogenesis***:* In physical cosmology, baryogenesis is the generic term for hypothetical physical processes that produced an asymmetry between baryons and antibaryons in the very early universe, resulting in the substantial amounts of residual matter that make up the universe

**Hubble's Law**: A law stating that the redshifts in the spectra of distant galaxies (and hence their speeds of recession) are proportional to their distance.

## 2.10 FURTHER READINGS AND REFERENCES


Felder Gary (2000) "The Expanding Universe" The Math and Physics Help Home Page http://www4.ncsu.edu/unity/lockers/users/f/felder/public/kenny/papers/cosmo.html Retrieved on March 3, 2011.

Villanueva, John Carl (2009) "Expanding Universe" Universe Today, August 3, 2009 http://www.universetoday.com/36492/expanding-universe/. Retrievedon January, 2011.

Aczel, A.D. *God's Equation: Einstein, Relativity, and the Expanding Universe*. New York: MJF BOOKS, 2003.

Barrow JD, Silk J. *The Left Hand of Creation: The Origin and Evolution of the Expanding Universe*. New York: Oxford University Press, 1993.

Eddington, A.S.*The Expanding Universe*. Cambridgeshire: Cambridge University Press, 1987.

Hawking, SW. *The Theory of Everything: The Origin and Fate of the Universe*. Beverly Hills, CA: New Millennium Press, 2002.

Schwerin A (1993) *The Expanding Universe : An Introduction to Philosophy*. San Francisco: EMText, 1993.

Brown, CS. *Big History: From the Big Bang to the Present*. New York: New Press, 2007.

Narlikar, J.V. *An Introduction to Relativity*. Cambridge: Cambridge University Press, 2010.

Nussbaumer H, Bieri L. *Discovering the Expanding Universe.* Cambridge: Cambridge University Press, 2009.

Russell, B. *Abc of Relativity*. New York: Routledge, 2009.

Schatzman, E.L. *Our Expanding Universe*. New York: McGraw-Hill, 1992.

Whittaker, H. *The Universe*. Mankato: Smart Apple Media, 2011.

# UNIT 3 WORLD MODELS

Contents



## 3.0 OBJECTIVES

- To study some of the theories or models – ancient and modern - universe.
- To see how our view of the world keeps on evolving.
- To a brief study the most important world model we have today.

## 3.1 INTRODUCTION

"Cosmos" is just another word for universe, and "cosmology" is the study of the origin, evolution and fate of the universe. Some of the best minds in history - both philosophers and scientists - have applied themselves to an understanding of just what the universe is and where it came from, suggesting in the process a bewildering variety of models, theories and ideas, from the Cosmic Egg to the Big Bang and beyond. Below are some of the main ones, in approximate chronological order. The main purpose of this unit is to see how our present world model is the result of continuous evolution of older ones. For convenience sake we have divided the different world models into a. ancient, b. philosophical, c. early scientific and d. contemporary scientific theories. For this part we shall base ourselves on "The Physics of the Universe" website (CTH 2011). After studying these models we focus a bit more on Big Bang model and beyond.

## 3.2 ANCIENT THEORIES

Brahmanda (Cosmic Egg) Universe: The Hindu Rigveda, written in India around the 15th - 12th Century B.C., describes a cyclical or oscillating universe in which a "cosmic egg", or Brahmanda, containing the whole universe (including the Sun, Moon, planets and all of space) expands out of a single concentrated point called a *Bindu* before subsequently collapsing again. The universe cycles infinitely between expansion and total collapse and so the process goes on without end.

Anaxagorian Universe: The 5th Century B.C. Greek philosopher Anaxagoras believed that the original state of the cosmos was a primordial mixture of all its ingredients which existed in infinitesimally small fragments of themselves. This mixture was not entirely uniform, and some ingredients were present in higher concentrations than others, as well as varying from place to place. At some point in time, this mixture was set in motion by the action of "nous" (mind), and the whirling motion shifted and separated out the ingredients, ultimately producing the cosmos of separate material objects, all with different properties, that we see today (CTH 2011).

Atomist Universe: Later in the 5th Century B.C., the Greek philosophers Leucippus and Democritus founded the school of Atomism, which held that the universe was composed of very small, indivisible and indestructible building blocks known as atoms (from the Greek "atomos", meaning "uncuttable"). All of reality and all the objects in the universe are composed of different arrangements of these eternal atoms and an infinite void, in which they form different combinations and shapes.

## 3.3 PHILOSOPHICAL THEORIES

Aristotelian Universe: The Greek philosopher Aristotle, in the 4th Century B.C., established a geocentric universe in which the fixed, spherical Earth is at the centre, surrounded by concentric celestial spheres of planets and stars. Although he believed the universe to be finite in size, he stressed that it exists unchanged and static throughout eternity. Aristotle definitively established the four classical elements of fire, air, earth and water, which were acted on by two forces, gravity (the tendency of earth and water to sink) and levity (the tendency of air and fire to rise). He later added a fifth element, ether, to describe the void that fills the universe above the terrestrial sphere.

Stoic Universe: The Stoic philosophers of ancient Greece (3rd Century B.C. and after) believed in a kind of island universe in which a finite cosmos is surrounded by an infinite void (not dissimilar in principle to a galaxy). They held that the cosmos is in a constant state of flux, and pulsates in size and periodically passes through upheavals and conflagrations. In the Stoic view, the universe is like a giant living body, with its leading part being the stars and the Sun, but in which all parts are interconnected, so that what happens in one place affects what happens elsewhere. They also held a cyclical view of history, in which the world was once pure fire and would become fire again, which is an idea borrowed from Heraclitus. (CTH 2011)

Heliocentric Universe: The 3rd Century B.C. Greek astronomer and mathematician Aristarchus of Samos was the first to present an explicit argument for a heliocentric model of the Solar System, placing the Sun, not the Earth, at the center of the known universe. He described the Earth as rotating daily on its axis and revolving annually about the Sun in a circular orbit, along with a sphere of fixed stars. His ideas were generally rejected in favour of the geocentric theories of Aristotle and Ptolemy until they were successfully revived nearly 1800 years later by Copernicus. However, there were exceptions: Seleucus of Seleucia, who lived about a century after Aristarchus, supported his theories and used the tides to explain heliocentricity and the influence of the Moon; the Indian astonomer and mathematician Aryabhata described elliptical orbits around the Sun at the end of the 5th Century A.D.; as did the Muslim astronomer Ja'far ibn Muhammad Abu Ma'shar al-Balkhi in the 9th Century (CTH 2011).

Ptolemic Universe: The 2nd Century A.D. Roman-Egyptian mathematician and astronomer Ptolemy (Claudius Ptolemaeus) described a geocentric model largely based on Aristotelian ideas, in which the planets and the rest of the universe orbit about a stationary Earth in circular epicycles. In terms of longevity, it was perhaps the most successful cosmological model of all time. Modifications to the basic Ptolemic system were suggested by the Islamic Maragha School in the 13th, 14th and 15th Centuries including the first accurate lunar model by Ibn al-Shatir, and the rejection of a stationery Earth in favour of a rotating Earth by Ali Qushji.

Abrahamic Universe: Several medieval Christian, Muslim and Jewish scholars put forward the idea of a universe which was finite in time. In the 6th Century A.D., the Christian philospher John Philoponus of Alexandria argued against the ancient Greek notion of an infinite past, and was perhaps the first commentator to argue that the universe is finite in time and therefore had a beginning. Early Muslim theologians such as Al-Kindi (9th Century) and Al-Ghazali (11th Century) offered logical arguments supporting a finite universe, as did the 10th Century Jewish philosopher Saadia Gaon.

Partially Heliocentric Universe: In the 15th and early 16th Century, Somayaji Nilakantha of the Kerala school of astronomy and mathematics in southern India developed a computational system for a partially heliocentric planetary model in which Mercury, Venus, Mars, Jupiter and Saturn orbited the Sun, which in turn orbited the Earth. This was very similar to the Tychonic system proposed by the Danish nobleman Tycho Brahe later in the 16th Century as a kind of hybrid of the Ptolemaic and Copernican models (CTH 2011).

**Check Your Progress III**

**Note**: Use the space provided for your answers.

1) How do Brahmanda and Bindu contribute to the ancient Indian view of the cosmos?

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2) What is Partially Heliocentric Universe?

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## 3.4 EARLY SCIENTIFIC THEORIES

Copernican Universe: In 1543, the Polish astronomer and polymath Nicolaus Copernicus adapted the geocentric Maragha model of Ibn al-Shatir to meet the requirements of the ancient heliocentric universe of Aristarchus. His publication of a scientific theory of heliocentrism, demonstrating that the motions of celestial objects can be explained without putting the Earth at rest in the centre of the universe, stimulated further scientific investigations and became a landmark in the history of modern science, sometimes known as the Copernican Revolution. His Copernican Principle (that the Earth is not in a central, specially favoured position) and its implication that celestial bodies obey physical laws identical to those on Earth, first established cosmology as a science rather than a branch of metaphysics. In 1576, the English astronomer Thomas Digges popularized Copernicus' ideas and also extended them by positing the existence of a multitude of stars extending to infinity, rather than just Copernicus' narrow band of fixed stars. The Italian philosopher Giordano Bruno took the Copernican Principle a stage further in 1584 by suggesting that even the Solar System is not the centre of the universe, but rather a

relatively insignificant star system among an infinite multitude of others. In 1605, Johannes Kepler made further refinements by finally abandoning the classical assumption of circular orbits in favour of elliptical orbits which could explain the strange apparent movements of the planets. Galileo's controversial support of Copernicus' heliocentric model in the early 17th Century was denounced by the Inquisition but nevertheless helped to popularize the idea.
Cartesian Vortex Universe: In the mid-17th Century, the French philosopher René Descartes outlined a model of the universe with many of the characteristics of Newton's later static, infinite universe. But, according to Descartes, the vacuum of space was not empty at all, but was filled with matter that swirled around in large and small vortices. His model involved a system of huge swirling whirlpools of ethereal or fine matter, producing what would later be called gravitational effects.
Static (or Newtonian) Universe: In 1687, Sir Isaac Newton published his "Principia", which described, among other things, a static, steady state, infinite universe which even Einstein, in the early 20th Century, took as true (at least until events proved otherwise). In Newton's universe, matter on the large scale is uniformly distributed, and the universe is gravitationally balanced but essentially unstable.
Hierarchical Universe and the Nebular Hypothesis: Although still generally based on a Newtonian static universe, the matter in a hierarchical universe is clustered on ever larger scales of hierarchy, and is endlessly being recycled. It was first proposed in 1734 by the Swedish scientist and philosopher Emanuel Swedenborg, and developed further (independently) by Thomas Wright (1750), Immanuel Kant (1755) and Johann Heinrich Lambert (1761), and a similar model was proposed in 1796 by the Frenchman Pierre-Simon Laplace (CTH 2011).

## 3.5 CONTEMPORARY SCIENTIFIC THEORIES

Einsteinian Universe: The model of the universe assumed by Albert Einstein in his groundbreaking theory of gravity in the early 20th Century was not dissimilar to Newton's in that it was a static, dynamically stable universe which was neither expanding or contracting. However, he had to add in a "cosmological constant" to his general relativity equations to counteract the dynamical effects of gravity which would otherwise have caused the universe to collapse in on itself (although he later abandoned that part of his theory when Edwin Hubble definitively showed in 1929 that the universe was not in fact static)
Big Bang Model of the Universe: After Hubble's demonstration of the continuously expanding universe in 1929 (and especially after the discovery of cosmic microwave background radiation by Arno Penzias and Robert Wilson in 1965), some version of the Big Bang theory has generally been the mainsteam scientific view. The theory describes the universe as originating in an infinitely tiny, infinitely dense point (or singularity) between 13 and 14 billion years ago, from where it has been expanding ever since. The essential statement of the theory is usually attributed to the Belgian Roman Catholic priest and physicist Georges Lemaître in 1927 (even before Hubble's corroborating evidence), although a similar theory had been proposed, although not pursued, 1922 by the Russian Alexander Friedmann in 1922. Friedmann actually developed two models of an expanding universe based on Einstein's general relativity equations, one with positive curvature or spherical space, and one with negative curvature or hyperbolic space. (CTH 2011 and Pandikattu 1999)
Oscillating Universe: This was Einstein's favoured model after he rejected his own original model in the 1930s. The oscillating universe followed from Alexander Friedmann's model of an

expanding universe based on the general relativity equations for a universe with positive curvature (spherical space), which results in the universe expanding for a time and then contracting due to the pull of its gravity, in a perpetual cycle of Big Bang followed by Big Crunch. Time is thus endless and beginningless, and the beginning-of-time paradox is avoided (Pandikattu 1999).

Steady State Universe: This non-standard cosmology (i.e. opposed to the standard Big Bang model) has occurred in various versions since the Big Bang theory was generally adopted by the scientific community. A popular variant of the steady state universe was proposed in 1948 by the English astronomer Fred Hoyle and the and Austrians Thomas Gold and Hermann Bondi. It predicted a universe that expanded but did not change its density, with matter being inserted into the universe as it expanded in order to maintain a constant density. Despite its drawbacks, this was quite a popular idea until the discovery of the cosmic microwave background radiation in 1965 which supported the Big Bang model. It may be noted that Jayant Narlikar, one of the most famous Indian astronomers is an ardent supporter of a modified steady state universe (Narlikar 2010).

Inflationary (or Inflating) Universe: In 1980, the American physicist Alan Guth proposed a model of the universe based on the Big Bang, but incorporating a short, early period of exponential cosmic inflation in order to solve the horizon and flatness problems of the standard Big Bang model. Another variation of the inflationary universe is the cyclic model developed by Paul Steinhardt and Neil Turok in 2002 using state-of-the-art M-theory, superstring theory and brane cosmology, which involves an inflationary universe expanding and contracting in cycles.

Bubble Universe: Drawing from the recent quantum mechanics Russian-American physicist Andrei D. Linde proposes a "bubble universe." The universe consisting of a whole set of bubbles has no clear development or final state; new bubbles will begin as offspring of others. He therefore argues that life appears again and again in the bubbles. Even more strongly he hints at the possibility of travelling or at least communicating between bubbles. The conditions within the bubbles is that the vacuum energy density is extremely close to zero. This shows the potential practical importance of research on the vacuum energy density. According to Drees, "unfortunately (or, may be, fortunately) it may take as much as 10-5000000 years until the significance of the current work on this problem will be fully appreciated." The pioneering work of physicists Sidney Coleman and Frank De Luccia on "Gravitational Effects on and of Vacuum Decay" throws prospects for the entire cosmos based on such a quantum cosmology. From quantum mechanical perspective what appears to us as vacuum may be in reality "seething with ephemeral quantum activity, as ghostly virtual particles appear and disappear again in a random frolic." Such a vacuum state may not be unique; there could be several quantum states, all apparently empty but enjoying different levels of quantum activity and having different energy levels (Pandikattu 1999).

Multiverse: Going beyond the "bubble universe" the theory of multiverse is proposed, that grew as part of a multiverse owing to a vacuum that had not decayed to its ground state. The American physicists Hugh Everett III and Bryce DeWitt had initially developed and popularized their "many worlds" formulation of the multiverse in the 1960s and 1970s. Alternative versions have also been developed where our observable universe is just one tiny organized part of an infinitely big cosmos which is largely in a state of chaos, or where our organized universe is just one temporary episode in an infinite sequence of largely chaotic and unorganized arrangements (CTH 2011).

**Check Your Progress II**

**Note**: Use the space provided for your answers.

1) What is oscillating Universe?
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2) What is the significance of Bubble Universe?
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## 3.6 THE BIG BANG AND BEYOND

This paper elaborates the theory of Big Bang and later introduces the theory *inflation*, a modification of the standard "big bang" model of the history of the universe.

When Einstein formulated the general theory of relativity, he found that it was incompatible with a static universe; the equations predicted that the universe must either be expanding or shrinking. The prevalent bias against this conclusion was so strong that Einstein altered the equations of relativity in order to allow for a static solution. When Edwin Hubble found that the universe was indeed expanding, Einstein retracted this alteration, calling it the biggest blunder of his life. From that point forward the prevailing scientific viewpoint has been that of an expanding universe that at earlier times was much hotter and denser than it is today. Extrapolating this expansion backwards, we find that at a specific time in the past the universe would have been infinitely dense. This time, the beginning of the universe's expansion, has come to be known as the "big bang." (Felder 2002)

The big bang model has been extremely successful at explaining known aspects of the universe and correctly predicting new observations. Nonetheless, there are certain problems with the model. There are several features of our current universe that seem to emerge as strange coincidences in big bang theory. Even worse, there are some predictions of the theory that are in contradiction with observation. These problems have motivated people to look for ways to extend or modify the theory without losing all of the successful predictions it has made. In 1980 a theory was developed that solved many of the problems plaguing the big bang model while leaving intact its basic structure. More specifically, this new theory modified our picture of what happened in the first fraction of a second of the universe's expansion. This change in our view of that first fraction of a second has proven to have profound influences on our view of the universe and the big bang itself. This new theory is called *inflation*. (Felder 2002)

**The Big Bang Model**

For most of this century our view of the large-scale structure and history of the universe has been dominated by the big bang model. According to this model the universe at early times was a nearly uniform expanding collection of high energy, high temperature particles. A system that is uniform—the same everywhere—is known in physics as *homogeneous.* The small differences in density that did exist from one point to another are called *inhomogeneities.* As the universe expanded and cooled these small inhomogeneities were then amplified by gravity. The matter in regions with slightly higher than average density collapsed to form the structures we see today such as clusters and galaxies. Extrapolating backwards, on the other hand, that nearly homogeneous fireball would have had higher temperatures and densities at earlier times, ultimately reaching infinite density at a moment about 15 billion years ago. That moment is called the big bang (Ratcliffe 2009).

This model is in perfect accord with the theory of general relativity, which predicts that a homogeneous universe would expand and cool in exactly that way. Moreover, there have been many observational confirmations of the big bang model. These confirmations include the apparent motions of distant objects relative to us, the microwave radiation left over from the early universe, and the abundances of light elements formed in the first few minutes after the big bang. (Felder 2002 and Teerikorpi 2009)

We want to focus momentarily on the latter of these. An element is defined by the number of protons in a nucleus—one for hydrogen, two for helium, and so on. For roughly three minutes after the big bang the temperature of the universe was so high that protons and neutrons couldn't bind together into nuclei; the particles all had so much energy that the forces that hold nuclei together were too weak to make them stick to each other. Thus for those first three minutes the only element in the universe was hydrogen, i.e. single protons not bound to anything else. (A neutron with no proton is not considered an element.) As the universe expanded and cooled it eventually reached a temperature where the protons and neutrons could bind together, and different elements were formed. The formation of these nuclei from their constituent particles (i.e. protons and neutrons) is known as *nucleosynthesis* (Felder 2002).

Nuclear theory is well tested and understood. By applying it to a homogeneous, expanding medium at high temperature we can predict what relative abundances of different elements should have emerged when these nuclei were formed in the early universe. It turns out that only the three lightest elements, hydrogen, helium, and lithium, would have been able to form at that time. All of the heavier elements were formed much later in stars, and currently make up a tiny percentage of the matter we see in the universe. The predictions of the relative abundances of these light elements accurately match the observational data. This match is particularly important because it strongly suggests that the big bang model is an accurate description of the universe at least as far back as nucleosynthesis, i.e. three minutes after the predicted moment of the big bang. All of the other evidence for the theory, such as the microwave background and the motions of distant galaxies, relate to the universe at much later times, so we have no direct evidence for the accuracy of the big bang model before nucleosynthesis.

Despite this lack of direct evidence, it would be tempting to extrapolate further backwards and assume the big bang model to be an accurate description of the universe all the way back to the big bang. Such a complete extrapolation of the theory is not possible, however, because of certain limitations of our theories of high energy physics. When we talk about extrapolating backwards in the big bang model we are referring to running the equations of general relativity backwards to earlier times and higher densities. We know, however, that general relativity ceases to be valid when we try to describe a region of spacetime whose density exceeds a certain value known as the *Planck density,* roughly $10^{93}$ g/cm$^3$. If we try to consistently apply quantum mechanics and general relativity at such a density we find that quantum fluctuations of spacetime become important, and we have no theory that describes such a situation (Felder 2002).

It is almost certain that the big bang model gives an accurate description of the universe back at least as far as the time of nucleosynthesis. The earliest it could possibly be applied would be the Planck era. If we were to consider it valid all the way back to the Planck era we would have to suppose that all the very fine-tuned initial conditions we observe such as homogeneity and flatness were present from the beginning, presumably as a result of some unknown quantum gravity effects. Even given this assumption, however, it is unclear how the theory could avoid the production of relic particles that would destroy the successful description it has made of the later universe (Ratcliffe 2009).

It would be wonderful if a theory existed that with a minimum of assumptions could explain the initial conditions such as flatness and homogeneity, eliminate all high energy relic particles, and then segue into the big bang model itself by the time of nucleosynthesis. In 1980 Alan Guth proposed such a theory, known as *inflation.*

**Inflation**

The basic idea of inflation has to do with the rate at which the universe is expanding. When I use the term "rate" in this context I don't mean a speed. In an expanding universe the distances between galaxies are increasing, and the rate of expansion essentially refers to how long it takes for all of those distances to double. In the standard big bang model the universe experiences *power law expansion,* meaning the doubling time gets longer as the universe expands. For example, in our current power law expansion distances in the universe were roughly half their current value about 10 billion years ago, but they won't be twice their current value until about 30 billion years from now. By contrast, if the doubling time stays constant then the expansion is referred to as *exponential.* Inflationary theory says that before our current power law expansion there was a brief period of exponential expansion (Felder 2002).

Exponential growth can be much faster than power-law growth. In the simplest models of inflation the universe would have expanded by a factor of over ten to the ten million in a fraction of a second. There are two obvious questions raised by this idea: What mechanism would cause such an expansion to occur and what would be the consequences if it did?

It is nothing short of remarkable that from our vantage point, sitting at one point in space and at one time in cosmic history, we have been able to discover as much as we have about the history of our universe. While there is a great deal we do not understand about the very early times after the moment we call the big bang, the last twenty years have seen an explosion of progress in both our theories and our observations. As we improve in both of these arenas our understanding will undoubtedly change.

Will the theory of inflation survive those changes? I believe it's too early to answer that question with any confidence. As a model it has great appeal for a number of reasons. In particular, it explains a lot of features of the universe in a simple way with relatively few assumptions, and it seems to arise naturally in the context of our current theories of physics. In other words it seems highly likely that inflation would have occurred in the early universe, and if it did it would give rise to a universe much like the one we see. Moreover no other known theory can explain these features. Andrei Linde, one of the leading experts in inflation, once told me “Inflation hasn’t won the race, but so far it’s the only horse.” My personal suspicion is that if in a hundred years the theory of inflation isn’t part of our understanding of the early universe then it will have to have been replaced by something very similar to it.

In the meanwhile we can look forward to a lot of good tests of early universe physics in the next couple of decades. High sensitivity probes of the microwave background, searches for waves of gravity surviving from the early universe, and many other experiments are going to give us excellent tests, not only of inflation, but of our understanding of the universe in general (Felder 2002).

**The Inflationary Theory**

In 1981, a particle physicist named Alan Guth created a new theory. Guth knew about the matter in physics that explained how elementary particles got their mass. This matter is called scalar field matter. Combining the mathematical equations for scalar field with Einstein’s equations describing the expansion of the universe, Guth developed a theory in which large amounts of matter and energy were created from nothing! After matter and energy were created, the universe experienced an accelerated expansion, becoming exponentially large prior to continuing its evolution according to the big bang model. This theory has been worked on and modified by many cosmologists since its introduction (Felder 2002?).

## 3.7 CONCLUDING COMMENTS

Most scientists now believe that we live in a finite expanding universe which has not existed forever, and that all the matter, energy and space in the universe was once squeezed into an infinitesimally small volume, which erupted in a cataclysmic “explosion” which has become known as the Big Bang. Thus, space, time, energy and matter all came into being at an infinitely dense, infinitely hot gravitational singularity, and began expanding everywhere at once. Current best estimates are that this occurred some 13.7 billion years ago, although you may sometimes see estimates of anywhere between 11 and 18 billion years. The Big Bang is usually considered to be a theory of the birth of the universe, although technically it does not exactly describe the origin of the universe, but rather attempts to explain how the universe developed from a very tiny, dense state into what it is today. It is just a model to convey what happened and not a description of an actual explosion, and the Big Bang was neither Big (in the beginning the universe was incomparably smaller than the size of a single proton), nor a Bang (it was more of a snap or a sudden inflation) (BBBC 2010).

In fact, “explosion” is really just an often-used analogy and is slightly misleading in that it conveys the image that the Big Bang was triggered in some way at some particular centre. In reality, however, the same pattern of expansion would be observed from anywhere in the universe, so there is no particular location in our present universe which could claim to be the origin. It really describes a very rapid expansion or stretching of space itself rather than an explosion in pre-existing space. Perhaps a better analogy sometimes used to describe the even expansion of galaxies throughout the universe is that of raisins baked in a cake becoming more distant from each other as the cake rises and expands, or alternatively of a balloon inflating. Neither does it attempt to explain what initiated the creation of the universe, or what came before the Big Bang, or even what lies outside the universe (BBBC 2010). All of this is generally considered to be outside the remit of physics, and more the concern of philosophy. Given that time and space as we understand it began with the Big Bang, the phase "before the Big Bang" is as meaningless as "north of the North Pole".

Therefore, to those who claim that the very idea of a Big Bang violates the First Law of Thermodynamics (also known as the Law of Conservation of Energy) that matter and energy cannot be created or destroyed, proponents respond that the Big Bang does not address the creation of the universe, only its evolution, and that, as the laws of science break down anyway as we approach the creation of the universe, there is no reason to believe that the First Law of Thermodynamics would apply. (BBBC 2010)

The Second Law of Thermodynamics, on the other hand, lends theoretical (though inconclusive) support to the idea of a finite universe originating in a Big Bang type event. If disorder and entropy in the universe as a whole is constantly increasing until it reaches thermodynamic equilibrium, as the Law suggests, then it follows that the universe cannot have existed forever, otherwise it would have reached its equilibrium end state an infinite time ago, our Sun would have exhausted its fuel reserves and died long ago, and the constant cycle of death and rebirth of stars would have ground to a halt after an eternity of dissipation of energy, losses of material to black holes, etc.

The Big Bang model rests on two main theoretical pillars: the General Theory of Relativity (Albert Einstein's generalization of Sir Isaac Newton's original theory of gravity) and the Cosmological Principle (the assumption that the matter in the universe is uniformly distributed on the large scales, that the universe is homogeneous and isotropic). The Big Bang (a phrase coined, incidentally, by the English astronomer Fred Hoyle during a 1949 radio broadcast as a derisive description of a theory he disagreed with) is currently considered by most scientists as by far the most likely scenario for the birth of universe. However, this has not always been the case, as the following discussion illustrates (BBBC 2010).

**Check Your Progress III**

**Note**: Use the space provided for your answers.

1) How do you respond to the question: 'What happened before the Big Bang?'?

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2) How is the first law of thermodynamics related to Big Bang?

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## 3.8 LET US SUM UP

We have studied the different world models. History tells us that best model we have (the modified standard model) will give way to a better one in the near future.

## 3.9 KEY WORDS

**Brahmanda**: "Egg of God," or "Cosmic egg." The cosmos; inner and outer universe. It also designates a division of infinite time.

## 3.10 FURTHER READINGS AND REFERENCES

BBBC (2010) "Big Bang and Big Crunch "http://www.physicsoftheuniverse.com/topics_bigbang.html. Retrieved on Jan 12, 2011.

Berman, M.S. *Introduction to General Relativity and the Cosmological Constant Problem*. New York: Nova Science Publishers, 2007.

Calle, C.I. *The Universe : Order without Design*. Amherst, N.Y: Prometheus Books, 2009.

Chow, T.L. *Gravity, Black Holes, and the Very Early Universe: An Introduction to General Relativity and Cosmology*. New York: Springer, 2008.

CTH (Cosmological Theories through History) (2011) The physics of the universe http://www.physicsoftheuniverse.com/cosmological.html. Retrieved on March 2, 2011.

Fang L and Ruffini R. *Cosmology of the Early Universe*. Singapore: World Scientific, 1984.

Felder, Gary (2002) Beyond the Big Bang: *Inflation and the Very Early Universe* http://www4.ncsu.edu/unity/lockers/users/f/felder/public/kenny/papers/inflation.html. Retrieved on Janury 6, 2011.

Narlikar, J.V.*An Introduction to Relativity*. Cambridge: Cambridge University Press, 2010.

Pandikattu, Kuruvilla. "Eschatology: Scientific and Religious" *Jeevadhara* 39/170 April 1999. 154-164.

Ratcliffe, M. *Cosmology and the Evolution of the Universe*. Santa Barbara, Calif: Greenwood Press, 2009.

Teerikorpi, P. *The Evolving Universe and the Origin of Life: The Search for Our Cosmic Roots*. New York, NY: Springer, 2009.

# UNIT 4 SCIENCE AND RELIGION

**Contents**



## 4.0 OBJECTIVES

The unit attempts to bring in the contemporary discussion on the relation between the science and religion which was seen as opposing each other in the modern period.

## 4.1 INTRODUCTION

The subjects of science and religion are getting more important to man in the modern age. They are two great disciplines which, when relied on separately can be counter-productive, but when combined harmoniously can being about an all-round expression of human genius and total fulfillment. The literal meaning of the term religion is traceable to '*Religare*' which means bind together. Religion is the outcome of man's age for freedom. It is the outer manifestation of this great hunger for the infinite. Different religions represent different aspects of that struggle, but the whole of mankind, consciously or unconsciously, is moving towards that goal which is the end of religion. For Swami Vivekananda religion is realizing the divinity already in man. But majority of people go to church or temple or mosque for various favours of God and Goddess. There are rituals associated with religion and worship. There are two types of devotion to God: devotion without any motive and devotion for particular ends. But to-day, religion is used by some misguided youth for disrupting social harmony. We see tensions between Muslims and Jews in the Middle-East, Protestants and Catholics in Northern Ireland and Muslims and Hindus in the Indian sub-continent. Though religion is blamed for the evils of the society, really religion is not at fault. Persons misuse religion for their selfish gains either in the domain of politics or even in the domain of religious organizations.

## 4.2 THE JOURNEY FROM PRE-SCIENCE TO SCIENCE

In ancient times, conditions were not conducive for the development of scientific thought. Uncertainty, danger from natural forces, from wild animals and poisonous insects plagued the early man everywhere. He had neither an assumed home nor an assured food supply. He almost knew nothing as to why events around him happened the way they happened. Thousands of years must have passed in this scared and bewildered conditions of human mind. The conditions around early man confused him more than giving him knowledge. His explanations of the phenomenon around were actuated by unscientific wish-fulfilling and ego-guarding aims. Since knowledge was scant, imagination dominated the then explanations. Behind every natural process was posited an invisible deity. There came up wind-god, fire-god, river-goddess, mountain-god, death-god and so on. The sun, moon and the shining bodies in the sky, each one, became a deity to be feared, praised, prayed to and worshipped for favours. People started worshipping these deities out of fear and also for favours. Such worships became a regular routine and were even passed on to the following generations. All this is more a religion than a science. Yet we must accept that at that time those were the only explanations available and people were even satisfied with them. The rudimentary religions later on developed into ritualistic religions. The people were submissive and loyal to such religions. Religions came up much earlier to sciences.

The ancient religions had the following common features:

1. The invisible deities govern the visible
2. The invisible is better, more real and more virtuous than the visible
3. The invisible deities are omnipotent and anthropocentric conception of God was prevalent in those days.
4. The gods have heavenly existence and will curse human beings if they are angry and bless them when pleased. So the Vedic way of worship focused on worshipping the natural forces such as Agni, Varuna, Vayu etc to please them.
5. Rituals and traditions were followed to propitiate these deities
6. The religious person must surrender to the will of the God.
7. Any deviations from established religious tradition is the worst crime and to be severely punished.
8. Since God and religion control every activity of ours (individual - soul), before death, after death, one must be faithful to such a God.

If there has to be science, the individuals must liberate themselves from God and religion. This liberation may not always be absolute. In science we search for natural antecedents as the cause of any natural event. But such a thinking cannot even arise as long as we intensely believe that in the world everything is caused and governed by God. If we believe that every event is caused by the will of God, then scientific explanation of natural events is not possible. If in religions the transcendental explains the natural, in sciences we search for a natural explanation of the natural events. Unfortunately, even this seemingly obvious development did not take place for thousands of years. The Lokayatas who tried to adopt a natural and empirical position were not allowed to do that. They were harassed, condemned, ridiculed and even out cast. In ancient Greece similar attempts of Anaxagoras, Lucretius, Pythagoras, Thales, Socrates and others met with a similar fate. Religious fanaticism was an obstacle for the growth of science. Ages of faith have invariably been ages of persecution and cruelty. With renaissance, winds of free thinking started blowing. As a result of printing, knowledge became a common man's property. With the increase of travel and commerce, people became a little more broad-minded. People started realizing that independent thinking and human efforts pay more than what faith and prayer do. Then started, the trend of study at comprehensive explanation of the worldly events. The explanation of individual entities was replaced with the explanation of processes. Experimentation and instrumentation got a singe fillip. As a result, we are on the way to developing a science-founded and science oriented life. But even after renaissance the intolerant attitude of the orthodoxy continued. The priests refused to accept scientific explanations of natural events. The scientists were ridiculed, harassed and even jailed. Bruno was burnt to death for his heterodox views. The journey from pre-science to science has also been a journey of naturalisation of human outlook. As a cumulative effect of sciences over the past few centuries, the epistemology and ontology of sciences have been completely naturalised. The subject matter of the study of sources, the objectives of scientific study, the sciences of scientific knowledge obtained, theories of truth and error, concept of truth and reality, criteria of verification and falsification, methods the sciences adopt, the nature and general effects of scientific knowledge are all mundane phenomena, natural phenomena. The epistemology of science has been so much naturalized, has become so much objective in nature that the subjective element in the seekers of scientific knowledge has absolutely no place in it. There is nothing unnatural, anti-natural or super-natural in the scientific epistemology. There are three constituents of epistemology : the knowing subject, the known object and the sources and the nature of knowledge obtained. In sciences all these three factors are of natural type and there is nothing super-natural or divine in them. The knowing subject is a psycho-physical person and not the spiritual type of soul; the objects of knowledge belong to this world only and the sources of knowledge and the nature of knowledge obtained also belong only to this empirical world. For science there is no transcendental world or heavenly entities. Its epistemology as well as ontology is completely naturalized.

## 4.3 SCIENTIFIC INVESTIGATION

Investigations of the scientists differ from the mystical methods of theologians. Even religious persons claim that their statements are scientific. Therefore we should be clear in stating the conditions which must be fulfilled if some investigations can be called scientific. An investigation can be called scientific if it fulfills the following conditions: (i) The phenomenon under investigation must be of a publicly verifiable nature (ii) During the investigation scientific method is followed; (iii) The outlook of the investigator is scientific and (iv) Acquisition of knowledge should be the aim of the investigator.

Now let us take the case of the claims of astrology in India being a science. It does not fulfil any one of the conditions seen above. It believes that there are nine planets who affect our individual life in one way or the other. They are some sort of deities controlling our fate. The fate of the person is fixed by the position of these nine planets at the time of his birth. The nine planets of Indian astrology are: the sun, the moon, the Saturn, the Jupiter, the Mars, the Venus, the Mercury, *Rahu* and *Ketu*. The assumptions of Indian astrology are not corroborated by the findings of modern science. *Rahu* and *Ketu* do not exist at all. Modern science has proved that the sun is a star and not a planet; moon is a satellite of the earth and is not an independent planet; our earth, very much a planet and affecting us the most does not find a place in the list of planets of Indian astrology. The recently discovered planets, Neptune, Pluto and Harshal do not figure in it. Moreover, science has found that these planets are masses of inert matter revolving in the sky and cannot be considered to be deities who could be appeased by our offerings. Indian astrology even now speaks in the very terminology that it spoke when it was founded centuries ago. This unchanging but defective character of Indian astrology in spite of changes in facts prevents it from becoming a science and makes it more a part of religion. Astrologers all over the world do not accept the foundation of Indian astrology. Any science should be universal in its nature and claim. It should be a definite public fact. Unlike science the religious claims of different religions differ with one another. The objects of study of sciences are universal and unanimous in nature. But in religions the views on God, soul and Heaven are not the same for all religions. The Jains and the Buddhists do not accept God. And even those who accept God, e.g., the Christian, the Hindus and the Muslims differ widely about their conception of God and liberation. Scientific conclusion does not differ with one another. Even if there are differences though further investigations and research such differences are narrowed down so that universality is maintained. An investigation can be called scientific only if the field of study is empirical, public, verifiable and objective. For any investigation to be scientific, scientific method should be followed. The scientific method consists the following stages of investigation: (i) Observation (and experimentation) (ii) Hypothesis formation (iii) Generalisation and (iv) Verification. All these steps are public and verifiable. A scientist should be liberal, flexible, relative, dispassionate and shun all finalism, absolutism and sentimentalism: Scientific investigation should he carried out purely with the intention of obtaining knowledge.

## 4.4 SCIENTIFIC AND RELIGIOUS OUTLOOKS

1. Theologians criticise the empirical knowledge of the scientists. According to them, the scriptures cannot be disputed. Only the scriptures are infallible and not the conclusion of the scientists. But the scientists are not rigid in their outlook. For them the scientific quest is a continuous process that will go on for ever. All the scientific truths are only provisional. If the future findings invalidate the present truths, the scientific truths will also change accordingly. There are no permanent and absolute truths in science. But religion does not accept relative truths.
2. Scientific attitude is an open-minded approach. It is always open to correction. But a religious approach is a closed-minded approach. If two scientists argue about something, they will have enough common ground. But in a debate when different religions are arguing their case, no one will yield to the others even an inch of ground. They will not hear what the others are saying. They will go on insisting upon their own point. The scene will be full of emotional out bursts coming to no understanding.
3. Religions hold that complete truth had been given to us by the prophets, they are always looking backward to the past; but scientists look to the future possibilities for human welfare.
4. Scientific and religions attitudes are distinguishable not from the contents of the beliefs but from the manner in which the beliefs are held. If they are held passionately and expressed emotionally, the outlook is religious. If the beliefs are held dispassionately and are expressed in a cool way, the outlook is scientific.
5. The scientific outlook treats facts as its ultimate authority and not certain persons or scriptures. It is concerned with what is true and false. It does not think that “our” truth is higher than “their” truth. Truth according to it is universal and common to all.
6. Scientific outlook is a rational enquiry attempting to find out cause-effect relations among events. Any scientific hypothesis must be verifiable.

7. In religions we are told that one who has faith will benefit and are also warned that one who doubts will perish. In the field of sciences the case will be just the opposite. Here one who only keeps faith and does not enquire any further will perish while the one who keeps on doubting and examining the current explanations, his knowledge will improve and will be benefitted.

**Check Your Progress I**

**Note**: Use the space provided for your answers.

1) Demonstrate the evolution of science from pre-scientific era.

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2) Briefly explain the Scientific investigation.

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## 4.5 SCIENTIFIC PERSPECTIVE OF TRUTH

In the process of acquiring knowledge there is a tripartite unity between the knower, the known and the knowledge. The truth according to the scientists is Matter or the objective world. For religion, the truth is God which is both immanent and transcendent. Since the scientists don't consider the trans-empirical existence as real, they don't accept God for the object of study. We can find the scientific approach to Reality even in ancient India and Greece. The great and original thinkers like Kapila, Gautama, Kanada and others worked out their empirical systems entirely based upon methodical knowledge and scientific analysis. As for example, modern science has discovered that various forces of nature like electricity, light, heat motion gravitation etc., are so many expressions of eternal cosmic energy. The atomic theory states that matter can be reduced to ultimate particles called atoms. It was first discovered in India by Kanada, the author of the Vaisesika philosophy and in Greece by Democritus, Leucippus and Lucretius. It is said that many Greek philosophers from Democritus onward had also imagined matter to consist, in the last resort, of hard indivisible pellets and those pellets were at first called "atoms" which were incapable of being divided. Anaxagoras maintained that those pellets possessed in itself all the characteristic properties of the substance to which it belonged. After a long time John Dalton, Lavoisier, Maxwell and other scientists made experiments on atom and considered it to be an essential ingredient of physical science. The physicist of the 19$^{th}$ century found that all matter is possessed of inertia and is capable of motion. They said that energy is matter, or is in atom which can exist in a number of forms and can change about almost endlessly from one form to another, but it can never be utterly destroyed.

In 20$^{th}$ century Dalton's atomic theory was disproved. His theory that atom cannot be divided was rejected by the scientists. Their theories proved that atoms can be divided into sub-atomic particles such as electron, proton, neutron, positron, meson etc. Albert Einstein proved that matter can be transformed into energy through the following equation : $E = mc^2$ where 'E' is energy ‘m’ is the mass of the object and ‘c’ is the velocity of light. The credit for rejecting Dalton’s atomic theory goes to Crookes, Lenard and J.J. Thompson. In 1897 Thomson showed that the fragments of atoms were identical no matter what type of atom they came from; they were of equal weight and they carried equal charges of magnetic electricity. On account of this last property they were called “electrons”. In 1911 Ernest Rutherford through his experiments revealed the architecture of atom; the atom to be constructed like the solar system, the heavy central nucleus playing the part of the sun and the electrons acting the parts of the planets. Rutherford’s experiments were afterwards extended by Niels Bohr and others. Modern science believes in the law of conservation of energy according to which the total amount of energy present in the universe is constant. Therefore the atoms and sub-atomic particles of the atoms are indestructible. However the scientists are unable to provide the causal explanation for the existence of matter in the universe. Matter and energy present in the universe are taken for granted by the scientists. To the question, ‘who created the matter’ (which is the Truth for the scientists) there is no satisfactory answer from the scientists.

To know the truth in science, the scientists depend upon sense perception and experimentation. The scientific method has the following stages: (1) observation (2) Hypothesis (3) verification and (4) scientific law. The intellectual analysis of the data collected through observation and verification of the hypothesis helps the scientists to arrive at conclusions. The scientists don’t consider mystical intuition or insight to arrive at conclusions. The scientists don’t consider mystical intuition or insight as the valid methods to arrive at conclusions.

## 4.6 RELIGIOUS PERSPECTIVE OF TRUTH

Truth according to religions is God. The truth which is absolute is called Brahman by the Vedantins. The Vedantic conception of Brahman is impersonal and the Hindu religion believes many personal gods. For the Vaisnava sect the God is Vishnu who incarnates as Rama, Krishna, Narasimha etc. For the Saiva sect, the God is Siva who appears as Ardhanareeswara (the dual form of Siva and Parvathi). The seekers of truth follow the method of meditation if the goal is self-realisation. Those who believe in personal God follow the paths of *Jnana*, *Bhakti* and *Karma* to have communion with God. However *yoga* and meditation are conducive in realizing the goals where the goal is spiritual union with the Brahma or communion with God. The Hindu religion believes in the Immortality of Soul, *Karma* and Rebirth which are interrelated with each other. Therefore whether the truth is Absolute Brahman or personal God, there is no disagreement among the believers about the interrelatedness of the Immortality of soul, *Karma* and Rebirth.

**Taoism**

The Chinese looked upon Tao as the Absolute Reality, anterior to and higher than heaven. It existed even before manifested God arose and before time began. It is the first cause of all existence, manifesting itself in the creator and the created universe. It is the eternal, unchanging and all-pervasive principle from which all things proceed, the goal to which all things tend. Only one who is eternally free from earthly passions can apprehend the spiritual essence of Tao. Out of Tao comes the one which produces the two primary essences, the ‘Yang’ and the ‘Yin’, the male and the female, light and shade, which give birth to heaven, earth and man. The interactions of yang and yin result in the production of all creatures. Tao is in man though it is generally unmanifested. If we are to regain our tranquility, we should set out on the quest of Tao. The Tao is potentially available to all and so each one has to treat others with sympathy.

**Judaism**

The religion of the Jewish people is called Judaism. The Jewish doetrine believes in God who is both immanent and transcendent. He is greater then the world and separate from it and yet he works in the universe by means of his "wisdom" which is an emanation from him and yet has no separate existence from him. God is in heaven and yet the earth is his footstool. The universe is one uninterrupted revelation of the Divine. Only angels can come into relations with the holy God and not the impure men. Only through deep spirituality and prayer men can bring about changes in the material world.

**Greek Religion**

There are two currents of thought in the ancient Greek religion, the Homeric and the Mystic. According to Plato the end of life is "to become like God". True piety is to be a fellow worker with God. Like Hindu Pantheon wherein there is a god each for fire (Agni) air (Vayu), Rain (Varuna) etc, in the Greek mythology too there are goddesses for prosperity, underworld, love etc. The Dionysiac mysteries are marked by wild ecstasy and several barabaric rites. The Orphic societies were generally attached to the workship of Dionysus. Those who were eager for communion with the Divine and anxious to attain peace of mind and position of hope and confidence were attached to the mystery religious. According to Plotinus, the Supreme in beyond existence, beyond life. It abides in a state of wakefulness beyond being. We cannot call it good; it is perfection. It is beauty, not the beautiful. The God whom we worship is the revelation, not the revealer. The source of revelation cannot be revealed. The goal of the intellect is the One, the goal of will is goodness; the goal of love and admiration is beauty. We can know the Absolute because we are ourselves, in the ultimate spirit not through discursive reason, but by some spiritual contact. The ecstatic state is a rare phenomenon gained only at the summit of spiritual development.

**Zoroastrianism**

Zoroastrianism is the religion of the Persians (Iranians). It has many common elements with the Vedic religion of the Indian Aryans. The *Avesta's asha* and the vedic *rta* are two variants of the same word and the underlying thought was fully developed in the period before the Indian Aryans and the Iranians separated. The highest principle is 'Ahura-Mazda' which acts according to changeless laws. It is believed that Zarasthura was born in response to the appeal of Mother Earth to help mankind to overcome evil. Ahura-Mazda is the Supreme being, the Lord of life and matter, the Cosmic Lord Iswara from whom have sprung '*Purusa*' and *Prakrti*'. The cosmic process is progressing towards the fulfillment according to the law of *asha*. Only those acts done out of love for the Supreme give us happiness and not those which are performed for one's own good. Unselfish work is the way by which human individuals attain their spiritual welfare and help the progress of the world. Love in Zoroastrian religion embraces the animal world also. Zarasthura promises those who follow his teaching everlasting life. To know the Supreme Ahura-Mazda and act according to his law *asha* one has to perfect one's nature through prayer and meditation. When we reach the goal we realize peace and unity.

**Buddhism**

Buddhism was founded by Gautama Buddha. The Buddha speaks of *bodhi* or enlightenment. It is an immediate, non-discursive, intuitive relation with Absolute Truth. It is not theatrical knowledge. It is knowledge that cut the roots of desire and is the result of concentration on the nature of Being. Since Buddhism preaches the philosophy of change it doesn't believe in a permanent soul. Man is ignorant and forgets his real nature and identifies himself with what he is not. He must get to know the truth beyond all phenomenal existence. *Prajna* is consciousness that transcends subject-object distinctions. The path to Nirvana is ethical path (eight fold path) Adopting the method of reason, the Buddha declined to answer certain ontological questions which he considered to be useless. His position is termed as Agnosticism. He rejected the rituals of Vedic religion and inequality in the society. He rejected the principle of authority, for truths accepted on authority and not ascertained and realized by personal effort are of no avail. In Mahayana Buddhism, the relation of the devotee to the absolute is medicated by faith and prayer and the devotee is helped by the grace and guidance of the divine Buddha. In all types of Buddhism, methods of concentration of thought are emphasized.

**Christianity**

Jesus Christ, the founder of Christianity was in disagreement with the teachings of the prophets of Israel. His reforming views over the Jewish religion made him the messenger of God. Jesus's personal experience is a supreme example of direct knowledge. His acts and utterances are penetrated with a feeling of fellowship with God. Jesus demands an inward renewal, and inner change. The Kingdom of Heaven is not a place in space but a state of mind. The Kingdom is present, here, immediate. “Repent, for the Kingdom of Heaven is at hand”. It is the attainment of Truth which makes for freedom or liberation. Jesus refers to the inner perfecting, the possible evolution of man. When he asks us to “repent”, he means not penitence or regret but inward revolution. True religion is the remaking of the soul by contemplative prayer and ascetic practice. The popularity of Christian religion in the world is due to its Mysticism which includes the “service to humanity” as its essential theme.

**Islamic Religion**

The central feature of Islam is the worship of God and acknowledgement of Him as the Absolute Lord. Muhammed, the founder of Islam rejected the worship of men and idols, of stars and planets on the principle that whatever rises must set, whatever is born must die, whatever is corruptible must decay and perish. For Muhammed, God is an infinite and Eternal being without form or place. God is what remains when we abstract from the unknown. He is present in our most secret thoughts, exists necessarily of his own nature, and derives from himself all moral and intellectual perfections. Quran is the sacred book of Islam. The Sufi tradition of Islam lays stress on personal experience of God. The human soul is a part of the absolute. God and man become one in the perfect man, the prophet is the final cause of creation. Unlike Hinduism, Islam lays stress more on ethical teachings than on metaphysics. The mysticism of Judaism, Christianity and Islam regards the theistic conception of God as determinate and inadequate.

The above account of Truth portrayed by different religions are like various languages in which God has spoken to man. Western forms of religion are inclined to hold that one definition is final and absolute and others are false. In India, each definition represents a *darsana* or a view point. If religious truth is seen by different groups in different ways, it is not to deny that truth is ultimately one. It is wrong to exaggerate the doctrinal differences, overlooking the common basis, the universal fact underlying the historical formulation. The diversity of dogmatic interpretations tends to diminish as we climb up the ladder of spiritual perfection. The variety of religious symbolism is due, not to the nature of the experience as such, but to the prevailing theological or metaphysical conception of time and place. If any one tells us that his view of the Supreme is final, it is only human judgement which need not be taken as infallible.

## 4.7 REASON AND FAITH

Science and religion as subjects of study focus on the two essential concepts: Reason and Faith. There is no science without reason and there is no religion without Faith. Attempts to synthesis reason and faith were made as early as 13th century by the Franciscan school men of Christianity. Franciscans were less orthodox than Dominicans. Between the two orders there was keen rivalry. St Thomas gave his proofs for the existence of God by using Aristotle's logic and argument. There are there ways of knowing: by reason, by revelation and by intuition. Therefore even in matters of faith, logical reasoning and sense-perception played a vital role in medieval period. Scholasticism as a school of philosophy paved the way for bringing reason closer to faith. The very fact that St. Thomas accepted a posteriori proof of God's existence reveal that reason and faith cannot be separated. Among the five proofs for the existence of God the first there proofs proceed directly from the given facts of experience.

1. First, proof is from motion
2. Second, the series of efficient causes
3. Thirdly, from the series of contingent causes.

According to Aquinas there is fundamental difference between man and God. Man is finite and a creative of God whereas God is infinite and the creator of man. He transcends both the world and the man. Human intellect can know God through sensible objects.

From the Indian perspective faith becomes the very basis of rational investigation. But this faith (*Sraddha*) is different from that usual idea of faith as mere static *visvasa* or belief, swallowing everything that is said by any authority without subjecting it to evidential tests. We can see the scientific and rational and human aspects of *sraddha*; and all physical science, all religion, and all human life itself needs this type of *sraddha*. What does *sraddha* means in the physical sciences? It means a faith in the meaningfulness of the universe. A scientist cannot investigate into nature unless he has a prior feeling that nature is worth investigating. Without that faith he cannot get even the impulse to undertake his scientific inquiry. Viewing faith from the point of view of scientific reason, Sir Arthur Eddington (The philosophy of physical science, p.222) says : "*In the age of reason, faith yet remains supreme : for reason is one of the articles of faith*".

**Check Your Progress II**

**Note**: Use the space provided for your answers.

1) How do Religions approach truth?

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2) Critique on role of Reason and Faith in quest for truth.

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## 4.8 LET US SUM UP

Albert Einstein in his essay on, *Science and Religion* says, "Now, even though the realms of religion and science in themselves are clearly marked off from each other, nevertheless, there exist between the two strong reciprocal relationships and dependencies. Though religion may be that which determines the goal, it has nevertheless, learned from science, in the broadest sense, what means will contribute to the attainment of the goals it has set up. But science can only be created by those who are thoroughly imbued with the aspiration towards truth and understanding. This source of feeling, however, springs from the sphere of religion. To this there also belongs the faith in the possibility that the regulations valid for the world of existence are rational that is, comprehensible to reason. I cannot conceive of a genuine scientist without that profound faith. The situation may be expressed by an image: *"Science without religion is lame, religion without science is blind"*. The above passage from Einstein's book, *of My Later Years*, reveals that he is in agreement with the Indian view that Faith and Reason are complimentary to each other. The conflict between Reason and Faith can be overcome in Spiritual life according to Vedanta.

## 4.9 KEY WORDS

*Sraddha:* Faith which is dynamic.

*Visvasa:* Belief which is static.

## 4.10 FURTHER READINGS AND REFERENCES

Perera, Ariyapala. *Science and Human Values*. New Delhi: Global Vision Publishing House, 2005.

Pandikattu, Kuruvilla. "Eschatology: Scientific and Religious" *Jeevadhara* 39/170 April 1999. 154-164.

Teerikorpi, P. *The Evolving Universe and the Origin of Life: The Search for Our Cosmic Roots*. New York, NY: Springer, 2009.

Utukuru, Paul (2003)"Ancient Hindu Cosmology and Modern Cosmology." Available on-line from "Metanexus: The Online Forum on Religion and Science" at http://www.metanexus.net/metanexus_online/show_article.asp?8021. 13 March 2003.

Raman, Varadaraja V. (2004), "Indic Visions in an Age of Science, III: Theories of Mind & Consciousness," Available on-line from "Metanexus: The Online Forum on Religion and Science" at http://www.metanexus.net/metanexus_online/show_article.asp?9193. 8 December 2004.