Humankind's fascination with the heavens is as old humankind. The sight of countless stars and the faint band of light which stretches from horizon to horizon must have been the cause of amazement and awe for the earliest homo-sapien as she trudged along the plains of East Africa. From the hunter-gatherer to our own times, every culture has developed its own cosmology, the system of beliefs or theories, which explain the origin and structure of the universe.

For instance, for the ancient Iranians, Ahura Mazda created both heaven and earth. Micronesians generally believed in at least three vertically arranged levels of the universe: the earth proper, the underworld, and heaven or the sky world. The ancient Egyptians thought that the faint band of light was the heavenly Nile flowing through the land of the dead ruled by Osiris, while the ancient Greeks likened it to a river of milk. Today, astronomers know that the band is actually composed of countless stars in the flattened disk of our own galaxy the Milky Way seen edge on. Interestingly, the word galaxy itself is derived from the Greek word for milk!

The objects of enquiry for the ancients were mostly the Sun (responsible for all life), the nocturnal moon and the strange objects called planets which instead of being fixed in the heavens (like the stars) wandered around. The apex in the description of heavens during classical antiquity was reached with the Greeks who developed an epicyclic model that would reproduce the observed planetary motions with astonishing accuracy. Of course, as with all other ancient cosmologies, the Greeks also assumed that the earth was fixed at the center of the universe. The model was purely empirical in as much as it did not attempt to address the reasons for why the motions were as they were. Nevertheless, it laid the groundwork for the paradigm that nature is not capricious but possesses a regularity and precision that can be discovered from experience and used to predict future events.

However, with Aristotle in the 4^{th} century BC, the systematic application of pure reason to the explanation of natural phenomena reached its extreme development. The great merit of Aristotle's system was its internal logic, a grand attempt to unify all branches of human knowledge within the scope of a single self-consistent and comprehensive theory. Its great weakness was that its rigid arguments rested almost entirely on aesthetic grounds; it lacked a mechanism by which empirical knowledge gained from experimentation or observation could be used to test, modify, or reject the fundamental principles underlying the theory.

The Aristotelian system prevailed for almost 18 centuries till the 16^{th} century when a Polish astronomer Nicolaus Copernicus proposed that the sun instead of the earth was at the center of the solar system. Gradually, the heliocentric view gained ground but not before heretics like Galileo and Bruno were tortured and burnt on the stake. With the use of the telescope, observational data began to be accumulated while Newton and others developed a theoretical framework for understanding the heavens.

We now know that far from being unique or special, our earth is a part of a planetary system around a non-descript star, the Sun, which itself is one of the hundred-billion stars which make up the Milky Way. The Milky Way is among the millions of galaxies which are arranged in clusters of mind boggling sizes. The extent of the universe is a staggering 10-15 billion light years! (a light year is the distance traveled by light , moving at 300 million meters per second , in a year. In conventional units, 1 light year is roughly equal to 95 billion kilometers.) All this and much more is known about the universe thanks to painstaking observations by astronomers over 400 years using instruments ranging from the optical telescope of Galileo to the Hubble Space Telescope.

One such astronomer, Edwin Hubble observed that the galaxies in the universe seem to be moving away from us. In 1929, he proposed that this is because of the general overall expansion of the universe. The Hubble Law marked a major turning point in modern thinking about the origin and evolution of the Cosmos. The announcement of cosmological expansion came at a time when scientists were beginning to grapple with the theoretical implications of the revolutions taking place in physics. On the theoretical front, Einstein had proposed his general theory of relativity around the turn of the century. This theory was soon established as the correct theory of gravitation, replacing the theory propounded by Isaac Newton about three centuries ago. With the huge volume of observational data and the theory of relativity providing the theoretical underpinning, the stage was now set for propounding a comprehensive theory of the structure and origin of the universe. Several models were proposed to explain the observations and around the mid 1960's, the standard cosmological model, also known as the Big Bang model (BBM) of the universe was recognized as the most complete model of the universe.

The BBM assumes that at the "beginning” of time, all the matter and energy of the universe was concentrated in a primeval fireball of extremely high temperature and density. Then with a massive explosion, (The Big Bang), the universe started about 10 - 15 billion years ago and has been expanding since. The model has had a spectacular success in explaining many diverse aspects of our observed universe. The recession of galaxies is explained because of the expansion. The abundance of light elements like hydrogen and helium predicted by the BBM is in agreement with the experiment. Another remarkable prediction of this model is the existence of a sea of microwave background radiation in the universe --- a fact which was confirmed in 1966.

Though the BBM was tremendously successful, there were still several fundamental problems with it. The microwave radiation observed was too isotropic i.e. the radiation observed from all direction looks the same. This is not possible in the Big Bang Model because it would violate the Theory of Relativity. Another problem was related to the amount of matter in the universe. According to the Theory of Relativity, the curving up of space is related to the amount of matter (or energy) in the space. We observe that our universe has an energy density which is very close to the value which gives us a flat universe. This in itself is not bad, but for these two quantities to be so close today, they would have to be equal to a fantastic degree in the past. Finally, even though for very large distances our universe is uniform and homogenous, the presence of galaxies, stars and indeed ourselves, indicates that there are inhomogenities at small distances. This distribution of galaxies has to be explained in any viable model of the universe and the BBM has no mechanism to really explain this.

Even with all these problems, BBM was the most complete theory we had of the universe. All the events which occurred 1 second or so after the Big Bang could be nicely explained in this model. The trouble was with events happening much earlier, roughly a trillionth, trillionth, millionth second after the Bang. The reason was that during this time the temperatures in the universe were very high, more than 10 billion degrees Centigrade and the behavior of matter at such extreme conditions was not well understood.

This picture started changing when cosmologists tried to explain the universe in the framework of new developments in a hitherto unrelated branch of physics, Particle Physics. In Particle Physics we deal with interactions between sub atomic particles which make up matter. It is interesting that to understand the largest (the universe) one had to go back to the smallest(the microscopic domain of the subatomic particles)! The interaction of particle physics and cosmology evolved into a new paradigm in the seminal work of Alan Guth in 1981. He proposed the idea of an "inflationary" universe to solve all the cosmological conundrums associated with the Big Bang Model. He showed that if the universe went through a phase of rapid expansion or inflation around 10^{-40} (i.e. trillionth, trillionth, thousandth) seconds after the bang, then all of the above problems would not arise. During this period the diameter of the universe would increase by a huge factor and all of the matter and energy in the universe would be created out of "nothing" !

A workable inflationary universe model needs a theory of matter at very high temperatures. The last two decades has seen a tremendous growth in our understanding of matter at very high temperatures. The theoretical framework for this is supplied by Grand Unified Theories (GUTs). These theories unify within a single framework, what are perceived as three independent forces; the strong nuclear force (responsible for holding the nucleus in an atom together), the weak force (responsible for the decay of the neutrons) and the electromagnetic force (responsible for the production of light). The Unified theories are difficult to verify experimentally because their distinctive predictions occur at extremely high energies. In fact, the only possible laboratory where one could test these theories would be the early universe since the energies available at the biggest accelerators are still a trillionth of what are needed to see the effects of Unified theories.

The overall picture emerging is one of an interlocking of particle physics and cosmology. A better understanding of one would lead to an increased knowledge of the other. The two seem to be irrevocably looped into a symbiotic relationship with observations of the very large and very small providing important inputs. However, even with the new developments in particle physics, one could only hope to understand phenomenon occurring 10^{-45} seconds after the bang, since before that even Einstein's General Theory of relativity is not applicable . One has to apply a quantum theory of gravity, i.e. a theory of gravity consistent with quantum mechanics. Such a theory has proved to be very elusive despite persistent efforts by physicists for over half a century now. Maybe, one day we will have such a holy grail. Then we could answer the question so eloquently put in the Mundaka Upanishad: “ What is That, Lord, which being known, all these become known?”

But there is another area where a revolution is taking place in cosmology. This is in our measurements of the properties of the universe. With the advent of the Hubble Space Telescope and other ground and satellite based telescopes, astronomers today are in a position to see to unprecedented distances in our cosmos. This is radically changing our view of the cosmos because in an evolving universe, the astronomer looks into the past by looking into the distant. The reason for this is the finite velocity of light. Objects which are very far away, if observed now provide us with information at very early times, because light reaching us now must have started a long time ago. For example, observing a galaxy which is 10 billion light years away, gives us information about the state of the galaxy 10 billion years ago! Thus a better observation of very distant objects will be crucial in our understanding of the very early universe.

One such object which is the subject of much debate currently is the supernova. A supernova is a massive star that having burnt out its nuclear fuel, explodes spewing out large quantities of energy in the form of radiation. Supernovae occur rarely, about once in 300 years in a galaxy, making them difficult to observe. Recently, two teams of astronomers have developed a method to observe and study them. They basically scan large parts of the sky and look for a supernova explosion in any of the thousands of galaxies. Once spotted, the astronomers then use a network of telescopes (including the Hubble Space telescope) to study them in detail.

What the astronomers have found has caused a stir in the community of cosmologists. Contrary to what was believed, the expanding universe is not slowing down but is instead accelerating! A universe expanding since the Big Bang will eventually slow down and stop expansion because the gravitational force governing the universe is attractive. Thus the stars, the galaxies, the computer and indeed everything in the universe attracts every other thing and this will eventually slow down the expansion. An accelerating universe on the other hand means that besides the attractive force of gravity, some form of repulsive force is also playing a part in the evolution of our universe.

The history of human thought on the nature of the Cosmos offers a number of remarkable lessons; the most striking of which is that the architecture of the universe is open to reason. But given the theoretical and observational advances made in the last century, are we close to answering all the questions about our physical universe? The answer, thankfully, is no, because otherwise science would become a religion! There are many fundamental questions which are still unanswered. For instance, our observations are still not good enough for us to unequivocally say what the ultimate fate of the universe is going to be. We do not yet have a theory which could explain the behavior of the universe at the very first instances of time. And in any case, even for areas where we feel we understand, new observations may have more surprises in store for us than we can imagine. After all, as Shakespeare remarked, " there are more things on heaven and earth, Horatio, than are dreamt in your philosophy”.