HOW BIG IS OUR UNIVERSE?

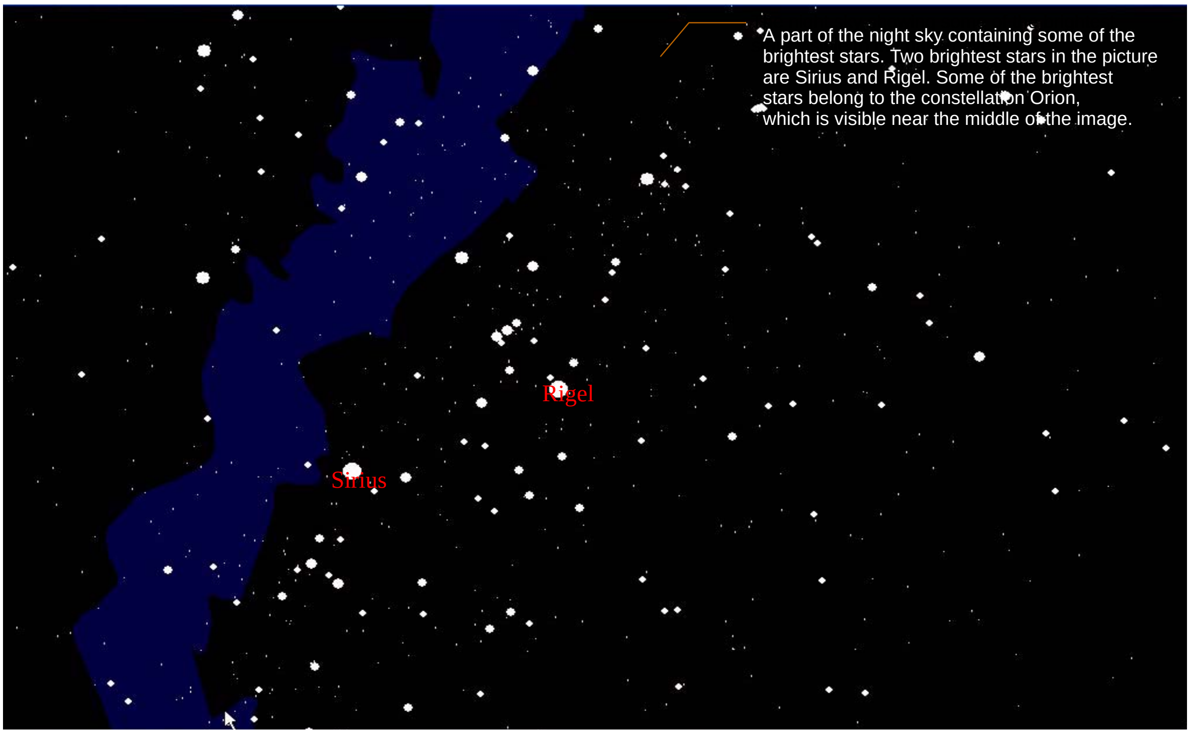
1

Only a few hundred years ago, before the discovery of the telescope, the people in the western world believed the sky to be made of a celestial dome. The stars were fixed on the ceiling of the dome. Above it there existed the sphere of the Heaven. God sitting in the Heaven was making the dome rotate in front of the mortal eyes. Therefore, with the passing of the hours, all stars were moving in the sky. Under this dome the sun and the moon and all the planets were moving in their own respective spheres assigned by the Heavenly Being. After the deaths the souls rose to these different spheres according to the merits they had gained in earthly life by doing services to God. Greater the merit the higher the souls rose towards the starry dome. The souls of those, who did not believe in God, and serve Him by giving services to the churches, were thrown into punishment in the dark realm of the Hell. The greatest sinners suffered horrendous physical tortures in the pit of the Hell, while the souls of the monarchs and bishops, guarding the throne of God, flew in the highest spheres. Any other view was considered blasphemy and punishable by death.

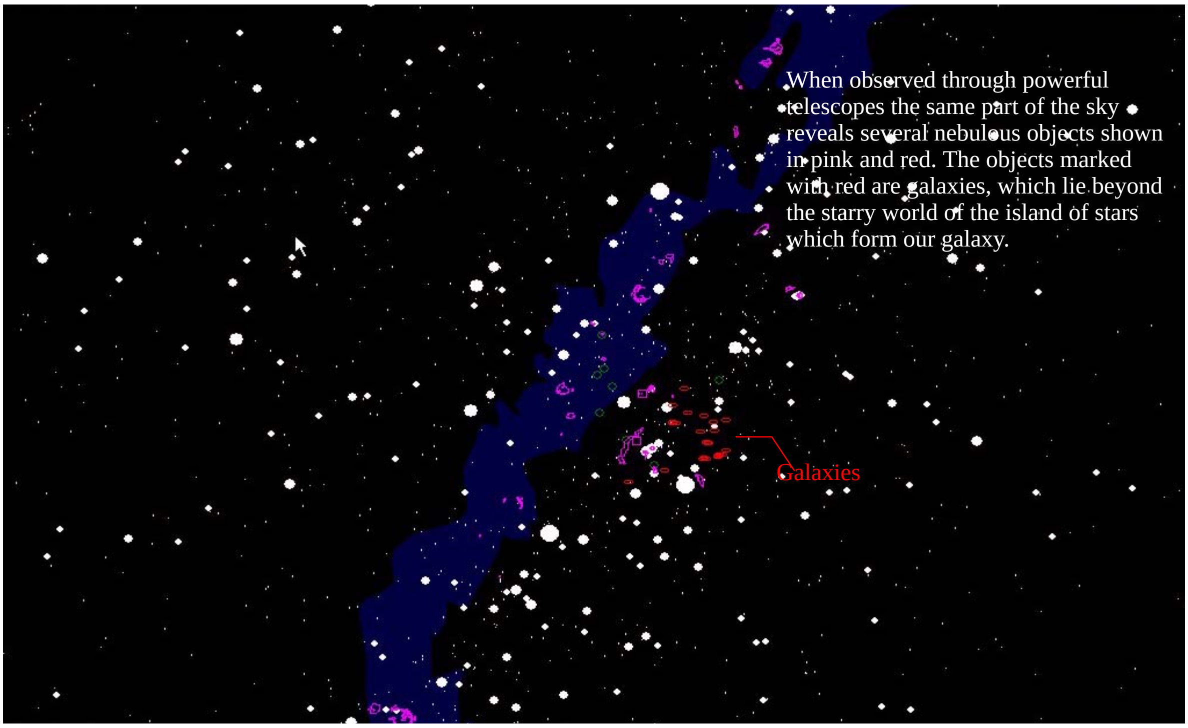
A few brave souls had to be sacrificed in the pit of the Hell before it became clear to mankind that the starry sky was not moving. Instead of the sphere of the fixed stars moving like the dome of the sky above our head, in fact, we earthly beings were moving with respect to the unmoving stars in the sky. It was not the sun and the planets moving around the earth but the earth and planets were moving around the sun, which was nothing but one of those stars in the sky. The sun was so big and blazing in the sky because it was the star nearest to us. This revolutionary change of the view that the earth was the centre of the universe, to a view that earth was moving around the sun, like the other planets in the sky, was brought by Copernicus and Galileo. Then Kepler and Newton came to set the foundation of science. They found the mechanical laws, which were turning the earth and the other planets in orbits around the sun.

Around the middle of the nineteenth century the view about the nature of the universe had changed to the believe that the universe was an infinite sphere filled with stars. The sun, which was away from the rest of the stars, and thus not much affected by their presence, was near the centre of this infinite universe. The planets were revolving around the sun following a mechanical law, which was decreed by a creator God.

Then came the question: How are these stars made? What make the sun so brightly shunning and supplying all these energies necessary for the creatures and the plants to live on Earth? For the first time around hundred and fifty years ago, it was realized that the same elements, which one finds on earth, were burning on the surface of the sun. The stars were nothing but fireballs of gases. In fact, most of them were balls of burning hydrogen gas. During the time of the period of the second world war, the intense research around nuclear bomb, led to the discovery that atomic nuclei were fusing together to create thermonuclear explosions in the centres of the stars and generating immense furnaces of heat ranging in millions of degrees.



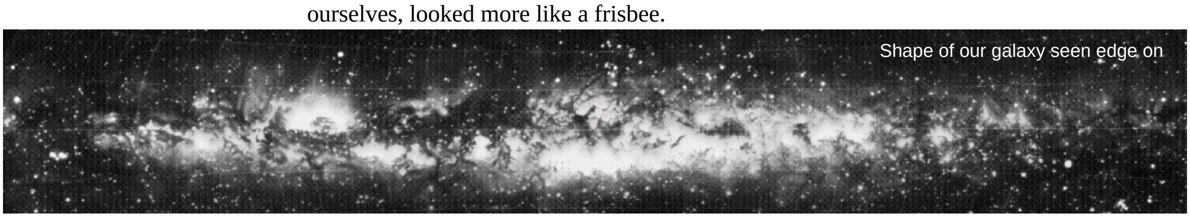
Are these objects in the sky infinite in number? The answers to this question came with the discovery of galaxies. The galaxies were first discovered as nebulous fuzzy objects stradling with other nebulous clouds strewn here and there inside the sphere of the stars. With the development of powerful telescopes in the first half of the twentieth century it could be revealed that these objects were nothing but islands made of stars and gas clouds in the universe. Each of these islands contained billions of stars like the ones hovering over our head at night. These galaxies were far outside the boundaries of the island of stars which hovered over us in the sky. The stars which we saw belonged to the island-universe which formed our galaxy, where the sun was a star among billions of other stars. Between these islands of the stars there existed intergalactic void. The starry world came to an end at the edges of the galaxy called the Milky Way galaxy. Beyond that there existed nothing until one arrived at the edges of another galaxy containing billions of such stars again.



With the construction of the Hubble telescope the astronomers were able to look closer and closer at these far away islands of stars. There were millions and millions of such galaxies in the sky. The universe seemed to be a sphere filled with galaxies.

How big is this universe? Where does the boundary of the universe filled with millions and millions of galaxies end? Where are we in this universe filled with so many island universes made of gas and stars?

It was observed that the sun was not anywhere near the centre of the starry sphere, which once constituted our view of the universe only a century ago. In fact, it was stradling at the edge of a galaxy, which possessed a flat disk- like structure at its outer edges, while containing a small spherical bulge at the centre. The island of the stars, where we found ourselves, looked more like a frisbee.



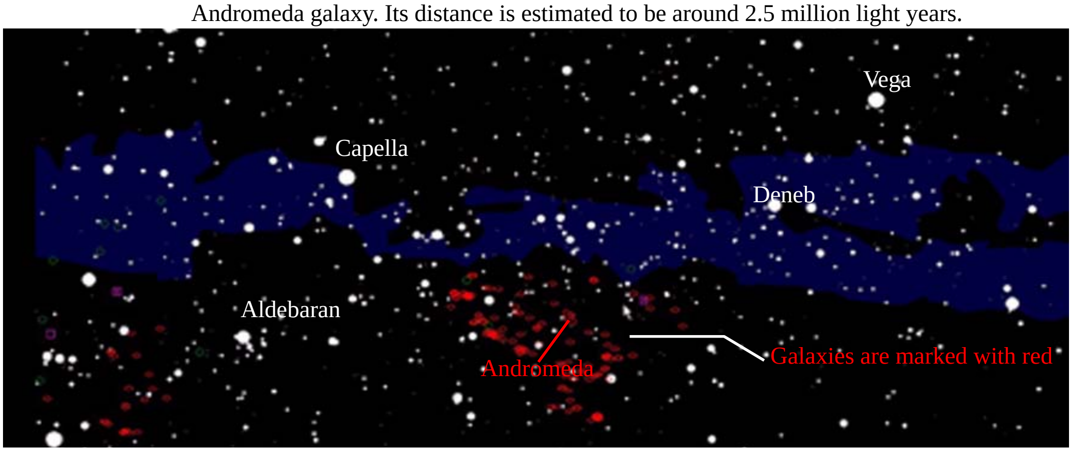
To describe how big is this island, which we call our Milky Way galaxy, it is hopeless to talk in the units of kilometers. Even the distance between the earth and the moon would be too small a unit to describe the dimension of the galaxies. The more appropriate unit to measure the distances of such cosmic objects would be the distance that one can travel by moving with the speed of light for one year. This distance is called a light-year.

One may grasp how long is one light-year by noting the fact that it takes only one second for the light to travel from the earth to the moon. If one travels to the moon back and forth more than 15 millions of times, one will then travel about a distance of one light-year.

The nearest star is the sun and the light takes about eight minutes to reach the earth from the sun. The sun is about 500 times more distant from us than the moon. The next nearest star is 4.3 light years away, which means that it is more than 240 000 times farther away from us than the sun. Sirius, which is the brightest star in the sky, is the fifth nearest star. It is 8.6 light years away. Rigel, which lies in the constellation Orion, is the seventh brightest star. Its distance is estimated to be about 90 times more than Sirius. Some stars are even farther away than Rigel. The light from those stars take many thousands of years to reach our eyes. Though they may appear as dots in the sky some of them are much more brighter and bigger than our sun. For example, Rigel is so bright that if it was placed at the distance of the sun it would have shone 40 000 times brighter than the sun. Sirius is not so bright. It is only about 23 times more shining than the sun. But it appears brighter than Rigel because it is much closer to us.

The sun is situated about 28 000 light years away from the centre of the island universe to which all the stars in the sky belong. The size of the disk that forms our galaxy is about 100000 light years across.

There are millions of such islands of stars in the universe. The galaxy closest to us is called Andromeda galaxy. Its distance is estimated to be around 2.5 million light years.



These innumerable galaxies are not evenly distributed in the sky. They form clusters of galaxies. A cluster may contain hundreds or thousands or more of such galaxies. Our galaxy together with Andromeda belong to a small local group of galaxies containing more than thirty galaxies. The local group is believed to occupy an area spanning more than 10 million light years.

The clusters of galaxies also are not evenly distributed in the sky. The clusters themselves clump together to form superclusters. The Local Group is a part of a larger structure called the Local Supercluster, or Virgo supercluster, which contains around hundred groups and clusters of galaxies. It is estimated to be about 200 million light years in diameter. The biggest supercluster so far observed is estimated to be nearly 500 million light years in size and it lies several billions of light years away.

Hubble Deep Field View showing the distribution of galaxies of different shapes

Do there exist even bigger structures than those already discovered? Where does the universe really ends?

One would need a theory to be able to answer these questions. The distances to galaxies and clusters can only be guessed by using a theoretical model to comprehend the dynamics of the cosmos. The distances of the objects mentioned above are derived from the theoretical model which relates the velocities, with which the galaxies move away from us, to their distances in space from us. This relation is known as Hubble law: The faster the galaxy moves, farther away it is from us. The velocity and distance bears linear relationship.

Einstein's Theory of General Relativity, which explains the nature of the gravitational force, lies at the foundation of our understanding of the cosmos today. The main idea of this theory is that if one was falling freely in a gravitational field, like a person riding in an elevator, which is broken from its chain and falling freely without coming across any obstruction on the way, would not know about the presence of the force of gravity, as long as he or she watches the motions of the objects around him or her inside the elevator. Thus gravity is equivalent to an accelerated frame, like the elevator. Then he generalized his theory of the Special theory of Relativity, which dealt with frames moving uniformly with respect to each other, to accelerated frames. In the Special Theory of Relativity he had already shown how time and space should be treated in equal footings in formulating the theories of nature. An he had introduced the idea that natural laws should be formulated in a four dimensional world, which consists of three space dimensions and one time dimension. The formulation of the General Theory in this four dimensional world led to a theory, which was rather complicated. As it involved mathematical aspects, which most physicists at that time were not used to, it became a difficult theory to understand. The force of gravity was equated with the geometrical curvature of the space-time. The existence of matter was causing dents in the space-time around it, and creating space-time curvature around the matter source. In turn, the space-time was dictating the matter to move in lines following the geometry of the space-time.

In his famous equation, which became the foundation of the modern cosmological theories, he put the geometrical entities of space-time on one side and equated it with the matter and energy terms on the other side. Such a mathematical equation was difficult to solve. In the 1920s solutions of the equation were found. These solutions were based on the idea that the universe was homogeneous and isotropic, which means in whatever direction one may move in the sky and wherever one picks samples of matter from the universe, the density of matter should be the same in all samples.While the solutions of homogeneous and isotropic universe were appearing, it was becoming more and more clear that there existed galaxies outside the starry sphere. The redshifted spectral lines from these newly discovered galaxies also indicated that they were moving away from the earthly observers.The solutions of the homogeneous and isotropic universe predicted that the universe should be expanding with time following the Hubble Law. In the beginning of time the universe started as a singular point. It exploded from that initial singular state, and since then the universe had been expanding. After some billions of years of expansion the universe has reached the size, which one observes today.

Using this theory, known as the big-bang cosmology, the cosmologist try to figure out the fate of the universe: Will it be expanding for ever without reaching any limit? Or, will the expansion halt one day and the universe will start contracting and become smaller and smaller ending in a final crunch? According to the theory the fate of the universe depends on the total amount of matter, which the universe contains. Therefore, observers on Earth are making their efforts to figure out how much matter are there?

The total mass of all galaxies observed through the emissions of visible lights seem not to represent the correct value. The sizes and the movements of the galaxies inside the clusters indicate that most matter in the universe may remain hidden as dark matter and therefore invisible to us. The questions of the dark matter still keeps the scientific community in a great darkness about the fate of the universe.

Though it is the standard view of the universe accepted by the majority, some brave souls deny the existence of a homogeneous and isotropic universe. In contradiction to a homogeneous and isotropic world one observes an in homogeneous universe made of clumps of structures punctuated by spaces of void. This clumpiness and inhomogeneity exist in all directions, every where in all scales so far observed. Instead of a sphere filled with galaxies in equal numbers everywhere, the universe appears to bear a fractal structure, which clump in a similar way at different scales. It is an intricate network of matter and void where regions of overdensities and underdensities are distributed to form a fractal pattern. The average densities of matter also seem to go down as one studies objects of higher and higher scales. A theory based on one density for all regions, irrespective of scales seem not to comply with what one observes in the reality.

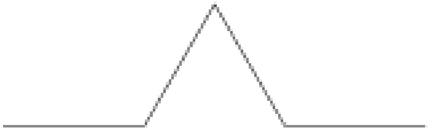
This is a point of contention between the group, who, by studying the galaxy surveys, conclude that the universe is a fractal, and their opponents, who are in the majority in number argue that, though clumpy in smaller scales, the universe will turn homogeneous once one has surveyed the universe in a big enough scale. So far there seems to exist no sign that the universe will show a homogeneity of galaxy distribution. If it is indeed a fractal then the standard cosmology must be abandoned and one would need a new theory to understand the theory of creation.

In this book I shall explain this new theory, where the universe is a fractal. It is not only a fractal but it could, in fact, be a multifractal. One may use a simple example of a cauliflower to describe the way the fractal universe may have been constructed. A cauliflower is made of similar smaller flowers, which in turn are made of similar flowers of even smaller size, which in turn again are made of even smaller flowers and so on. However by picking the smallest size and looking through a magnifying glass one will discover a structure which is similar to the structure of the original big cauliflower. The structures in the universe appears to be built in a similar way: The big universe images itself in the smaller and smaller cosmic objects, which it embodies. The example of the cauliflower is more simplistic than the hierarchical building of the universe. I shall describe it later.

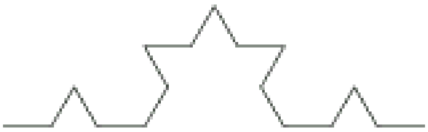
Where do these hierarchical structures end? Will the superclusters form super superclusters and super superclusters will in turn form super super superclusters and so on? The fractals in nature, where one may see such hierarchical construction, often are delineated by boundaries in space. However, the descriptions of these boundaries could be mathematically intriguing. In the geometry we have learnt from school, we know that a line possesses a dimension 1, a surface has a dimension 2, and the volume is 3 dimensional. In contradiction to this geometric concept, a fractal line may possess a fractional dimension between 1 and 2 and a surface may not be two dimensional. It may have a fractional dimension between 2 and 3 depending on the crumpling, which may hide fractals.

Use of the observational yardstick decides the length

One may survey more details of a fractal line by using smaller yardsticks. More one surveys the smaller details the length of the line increases more. A fractal coastline similar to a Koch curve will, in fact, have a length which will tend to infinity as one measures it with smaller and smaller yardsticks. So question is: What should we call its real length? Is it infinite or finite? In fact such a fractal line is not 1-dimensional like the line in the picture on the top. It has a fractional dimension. Koch curve is a 1.26 dimensional geometric object.



A Koch curve in first order



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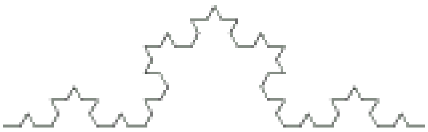
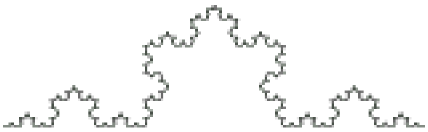


Third order embedding of the same



Fourth order embedding of the same

In the fractal universe the questions of finiteness or endlessness are mathematically intriguing and the answer depends on the way one makes the measurements. It is more relevant to ask if the hierarchical building in larger and even larger scales of cosmic structures may ever come to an end? The observations only reveal that the hierarchy exists up to the scale of the superclusters. Whether it may continue beyond that size can only be speculated only with a model which may explain the formation of such a fractal universe.

In the next part of the book I shall explain this new theory of creation.