

Understanding the physical and scientific limitations of method of telescopic observations for study of the Cosmos

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Abstract - *The study of cosmos is an essential area of research which can lead to the information regarding our origin. Numerous events that take place in the outer space can be studied in this regard. The most reliable method of study is that which involves observation with the aid of telescopes. The telescope works on the principle of magnifying the image of a distant object in space by a system of multiple lenses with the input being the light emitted from those objects. In this process, it is necessary to consider the physical limitations to the process, the most significant of which is the velocity of light in vacuum. This paper states various examples which prove the fact that what we are actually observing is the past and it is next to impossible to see the real time cosmic events. The chief aim of this work is to bring awareness towards the science of astrophysics and associated data analysis.*

Key Words: Cosmos, Astrophysics, Light, Star, Velocity, Observer

1. INTRODUCTION

In order to understand what has been the origin of the universe, cosmologists have been studying cosmic data since a long time using various methodologies like study of the cosmic waves, study of the gravitational waves, neutrino analysis, spectroscopy and naked eye observations using telescopes. The method of using telescopes has been the most ancient and widely used method as during those times technological advancement was not adequate to aid other means of research. As in case of telescopic observations, the light from the image entering the aperture is magnified and an image is formed using a set of lenses arranged in a certain manner. For the study, it is necessary that there is an observer on the other end or there is a recording device placed appropriately to record the data. Now the next point of concern is the relevance of data. Since whatever is observed through a telescope is a ray of light reflected or emitted from the surface of the object, there is certain time required for that ray to travel from the surface of the object to the aperture of the telescope. This itself reveals that what we actually see now is the past due to the time taken for light to travel all the way from that end to the observer. In the further sections, this concept has been elaborated. It is intended to educate and inform about this time delay to debutants in the field of astrophysics.

2. IMPORTANCE OF AN OBSERVER

In order to exemplify the importance of the presence of an observer, the most quoted example from Quantum

Mechanics can be quoted in this case too. According to that, A cat is placed in a box and on sealing, the box is kept unattended for a certain period. After completion of that predetermined period, when the box will be opened, the next question is that whether the cat is alive or dead?. The most logically correct answer would be the average of alive and dead. But in reality, the cat must be either alive or dead. In order to correctly ascertain the correct answer, an observer is required who would confirm the state of the cat. This shows importance of the presence of an observer during any scientific process to obtain correct results since mathematical results may be mathematically correct but may not be actually feasible like quoted in the previous example.

Following this principle, whenever certain study of the cosmos has to be undertaken, an observer should be present because depending on the point of time when the observations have been made, an estimate can be given as to how much are we looking into the past. The observer is primarily required to confirm the results and remain a witness of the observations.

3. VELOCITY OF LIGHT IN VACUUM

Experimentally, it is found that the velocity of light in free space also known as vacuum is 229792458 m/s[1]. This clearly shows that light can travel approximately three lakh kilometers in one second. This puts a limitation to the study of highly distant objects by using light or visible radiation of the electromagnetic spectrum. Since the velocity of light is not infinite, it is impossible to see the cosmos live. There is always a certain delay in what we see and what is actually happening. The farther we see, larger is the delay. Thus as a crude approximation, if we are able to see the farthest with respect to our present position, we could be able to see the most ancient universe although at present the picture may be totally different.

4. CONCEPT OF SEEING INTO THE PAST BY OBSERVING THE COSMOS

A point to be noted is that all cosmic calculations are considered taking earth as the reference. One earth year is equal to 365.25 days each of 23 hours 56 minutes 4.1 seconds with each hour made up of 60 minutes and each minute being 60 seconds long. Thus taking the basic unit of time as seconds, one earth year comprises of 3.147×10^7 seconds. To facilitate ease of cosmic calculations one of the units of distance used is light year. It is the distance travelled by light in one earth year. On calculating, the value of length

of one light year is 9.461×10^{12} km. Therefore there is a limitation of travel distance for light with a period of one earth year. This idea may seem weird but when we look into the clear night sky, we are actually seeing the past since the stars are so far away from earth that it takes years together for information in the form of light to travel from the star to earth. The nearest star after the Sun is approximately at a distance of 4 light years away from the earth which means if that were born on 1-Jan-2018, it would be seen in the sky only after four years from that day i.e. 1-Jan-2022 neglecting the error caused by the leap year of 2020. This also implies that if a star is located 10 light years away from the earth and is visible in the night sky, the light from its surface has taken 10 years to reach our eye or the telescope. This also means that if that star was to experience a supernova today, it would continue to appear normal for another 10 years while it is already nearing its death. And exactly 10 years from the day of the supernova, we would be able to witness that event in the sky. This itself proves that whatever we see in the night sky is nothing but the past while living in the moment is an illusion. In the next section similar comparisons have been made considering the two closest celestial bodies viz. the Moon and the Sun

5. SEEING THE PAST IMAGE OF THE MOON

As it is established by now that light travels at a certain finite speed due to which the space that we see is in fact the past, in the following sections explanations have been purported to exemplify this point. The moon is located at an average distance of 384400 km from the earth. On further calculations it can be realized that light takes nearly 1.672 seconds to travel from the moon to the earth. If further approximations of location and altitude of the observer are considered, it can be stated that the moon is approximately at a distance of 1 light second away from the earth. Therefore whatever image of the moon that is seen is 1 second old when it hits the observer.

6. SEEING THE PAST IMAGE OF THE SUN

Just like the moon is 1 light second away from the earth, the Sun is located at 8.33 light minutes away from the earth. Thus as light takes 8.33 minutes to travel from the Sun to the earth, the sun that we see is that it was 8.33 minutes ago. This idea can be extended further and it can be inferred that the farther we see, the more we see the past of the universe. An interesting factor that needs to be considered while carrying all this study is the constant expansion of the universe and the corresponding red shift that is caused. However, this factor is necessary only when distances need to be calculated while the observations which are nothing but visible radiations, take longer time to reach the observer considering the expansion of the universe.

7. SEEING THE PAST IMAGE OF THE STARS

It is known that the nearest star other than the Sun is located at a distance of four light years away from the earth. Thus light from that star requires four years to reach an observer

on earth. Thus every star that we see in the clear night sky is not its present state but is the past state. As stated earlier, depending upon the distance, a supernova caused now may be realized years later. This can be advantageous in certain means. By means of extrapolation, certain future events of the stars and other celestial bodies can be approximated. This can be helpful to predict any disastrous event that may cause mass destruction on earth since real time data cannot be obtained the farther we reach out into the cosmos.

8. EXPLANATION FOR OBSERVATION OF MOVEMENT OF STARS IN THE NIGHT SKY

Since time immemorial human beings have been highly curious about the cosmos and the ultimate question regarding our existence and the origin of the universe. In the Indian history, the sages have been experts in the prediction of various celestial events with the study of various constellations. But the key point to be noted is that Earth has been taken as the reference to carry out all the predictions. Everything as observed from the earth in real time is considered as the data to be undertaken for analysis. In this scenario, there is rather a smart assumption that over a short period of time, there are no significant movements in the relative positions of the celestial bodies.

According to the theory established till this point, we are aware that the stars seen in the night sky are actually their past images. But if closely observed, the stars in the night sky appear to move from east to west similar to the moon or the Sun. The question may arise that although we are not seeing the stars in real time and the universe is expanding continuously, how is it possible that we see relative movement of stars in the night sky. This can be understood as follows.

The moment a particular star starts to emit light, it starts to release photons in all the directions. If a particular point is fixed in space, once the ray of photons start getting visible at that point, there is a continuous streaming of photons in that direction. In this case too, the location and very presence of an observer is necessary. Further if the observer changes the position, he/she moves to another point where the same star has been emitting another stream of photons starting from the same time as earlier. If the process of changing the relative position is continued, it can be perceived that the star is moving in a particular path while the observer is stationary. Therefore relative motion of all celestial bodies depends solely upon the frame of reference considered.

9. THE ILLUSION OF REAL TIME EVENTS

By the points put forward till now, it is evident that due to the finite velocity of light, any events that we see from the cosmos are actually past events. For that matter, in our daily life, the image of a person sitting before us reaches our eyes after a delay of certain nanoseconds. Thus the question arises what is real time since whatever we are able to see around us is majority the past although we are living in the moment. This itself is the reason because of which time, which is considered

to be the fourth dimension is much of an illusory physical quantity which can be only be measured but not manipulated. This is a major limitation to the study of real time cosmic events. Be it any signal, for its propagation, the highest attainable velocity is that of light in free space. But due to the finite nature, only mathematical predictions can be made regarding events taking place in real time as the data obtained from measurements is that of the past and can only be used to confirm the previously made predictions.

10. CONCLUSION

Thus it can be concluded that as light travels with a finite velocity, analysis and measurement of real time cosmic events cannot be facilitated using telescopic observations since the real time data obtained is that of the past. This itself is a physical limitation since no other signal can effectively travel with a velocity greater than that of light. Because of this, only predictions can be made regarding the real time events happening at the moment. However, to derive certain positive aspects out of this physical limitation, the data obtained in real time can be used to verify the earlier predictions. By this, certain feedback can be obtained to improve the predictions in the future. It may be difficult to obtain real time data from the depth of cosmos but definitely, by the past data analysis, future predictions can be made with more accuracy to advance research in the direction of the quest of the origin of the universe.

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BIOGRAPHY



Gourav Vivek Kulkarni completed his Bachelor's Degree in Mechanical Engineering in 2017. His areas of interest include Thermal Engineering, Non conventional Energy sources, Astrophysics, Computational Fluid Dynamics and Machine Design.