

Time & Light Dilation in Black Hole-An Understanding of the Known and Unknown Facts



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Abstract: Understanding time has been quite a challenge for human being. Though we in general understand time but its implication for physics and the universe just make things very murky. In this paper we will discuss what is the relevance of time in the study of astronomy and how it impacts the Universe.

The great physicist Einstein has to be credited for introducing Time as one of the dimensions and after that the whole concept of looking into time has totally changed. We have understood space and time have an integral collaborative part to play in the vast Universe. Not only that through general relativity we have seen how time interacts with gravity and how time can be distorted by gravity. From the simple watch on our hand time has taken a great leap and made a mark of its own. Not to say the behaviour of time in certain celestial bodies still makes us wonder are we missing some aspect of time. Time acts peculiarly inside a Black Hole and forget Singularity as the concept itself puzzles our knowledge of physics. The concept of time as one of the dimensions has opened a lot of new avenues of re-search but also has brought with its lot of unanswered questions. It does not stop here when we try to analyse past, present and future with time though theoretically may be very easy to understand but once we add physics into its things get a bit complicated. The stars that we see in the night sky is actually past whereas the person travelling in space is future and we are present.

This paper will try to see if events can be placed in time and how light brings those events into our understanding. It must be understood that any event that is observed by human beings is due to the fact that light is falling on that object. In Big Bang several events happened in the beginning before the commencement of photon or light that does not mean time had not started. So, it is clear that light and time is not correlated though for human beings to look into an event light is of course needed. This paper will try to analyses the time and light dilation in a Black Hole and how that influences the concept of time. Also, this paper will try to understand how much more research is required to understand the whole concept of light, time and Black Hole.

Keywords : Big Bang, Black Hole, Einstein's special relativity theory, Gravity

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I. INTRODUCTION

Black Hole is black, well it may sound silly but that is the reality. Due to this very simple fact the interior of the Black Hole cannot be seen. This idea of Black Hole first came to John Michell in 1784. Though he could not give details of his calculation and thoughts but he assumed that in the universe there are huge unseen bodies from where light cannot escape. He presumed that these huge bodies are formed when the diameter of stars becomes 500 times bigger than that of the Sun. He also stated that these bodies can only be found by the gravitational effect of these bodies to different objects in the space. Though few scientists were excited of having an unseen star in the sky but slowly that fizzled out. Today it is known that he was right and there are such bodies like Black Hole and they are felt by the gravitational influence.

From 1784 till 1915 the scientific world had forgotten about the concept of Black Hole. In 1915 came Einstein with his path breaking theory of General Relativity [1]. Einstein showed how gravity had influence in the motion of light [2]. Scientists now had new ammunition in their hand so from 1915 lot of new concepts started flowing in. Scientists slowly looked into this subject in curiosity.

Karl Schwarzschild was pioneer solving Einstein's general relativity theory and came up with several points which Einstein himself did not solve [3].

Schwarzschild tried to find out the effect of severely compressed matter on gravity and energy. He was also pioneer in developing a radius beyond which time space collapses this radius is now known as Schwarzschild Radius or Event Horizon [6]. From this theory of radius, the concept of Singularity came into existence. This meant that once any article crosses this radius the article is lost in the eternal Time Space Singularity. This concept was very difficult to understand at that time al-so. Many scientists questioned that how can Singularity take place where there is zero volume but infinite mass. The whole theory was like a science fiction.

Then came another challenge that is, according to Einstein stars which are too large and have enormous radius will not be able to continue as star rather they will collapse [4]. In 1931 Subramanyam Chandrasekhar stated that above a certain limiting mass thing becomes unstable and would collapse.

This theory was opposed by many scientists then stating that even huge mass may not collapse by some unknown events.

In 1939 though Robert Oppenheimer stated that no laws of physics can stop a huge mass from collapsing due to the amount of gravitational pull that it would create [8]. Finally, the today's known concept of Black Hole was incorporated in our science. David Finkelstein first named Schwarzschild Radius as Event Horizon [7]. John Michell who first conceived it as discussed earlier had termed this as Dark Star but the name Black Hole was given by John Wheeler though this name was suggested by one of his students.

II. PROPOSED METHODOLOGY

The paper will be based on secondary data available till date and a mathematical analysis of the given formula of escape velocity. With the given formula of the escape velocity the paper will try to analyse that the escape velocity of Black Hole will be more than the speed of light that is 299792458m/s. The paper will analyse each event starting from boundary of space time to time dilation in Black Hole. The paper will analyse why light can not exit the Black Hole with the mathematical modelling of Escape Velocity. The paper will deduce the mathematical model for Schwarzschild radius for the Black Hole from the escape velocity. By this formula we will be able to analyse the way light behaves inside a Black Hole. Through secondary data and mathematical analysis the paper will try to analyse the difference between light and time.

III. ANALYSIS

Stellar Black Holes are formed when stars have consumed all its fuel and starts to collapse on its own weight due to gravitational pull [5]. Though different forms of degeneracy pressure stop this collapse is the actual star was small and forms White Dwarf or Neutron Star as we have already seen. But if the original star was huge then this degenerative pressure will not be able to halt the collapse even neutron degenerative pressure will not stop the star from totally collapsing to a Black Hole.

Here there are theories that quark stars can take place as after neutron degeneration pressure fails then quark degeneration pressure can try to stop the star from collapsing but the problem is that quarks are highly unstable and for the point of view of argument even if we take it into consideration that full quark star is formed then also because of its huge instability it will dissolve even before it is totally formed. It is presumed that in early star formation after the Big Bang super massive stars were formed and their collapse would have created Black Hole. It is also presumed that these black holes are sitting in the middle of each galaxy.

Recently a Black Hole by the name Messier 87 or M87 ejected jets more than 99% speed of light. Though here the light followed the law of physics but the speed seemed to be much faster than the speed of light due to the superluminal motion. It seemed light was travelling more than 6.3 times the speed of light.

A. Boundary in Space-Time

Well it is true that Black Hole cannot be seen as no light can pass through it but light can be seen till a part of the black hole and then disappear, this part of the Black Hole is called Event Horizon. In the Universe a particle can travel in any direction but once the particle comes near Event Horizon the particle is pulled towards it and once it enters the Event Horizon it is lost for eternity [10]. This event horizon is known as the boundary in space time. From this point onwards light or matter whatever enters it will remain inside it for eternity. This time dilation has puzzled the world of physics as no laws stands true.

B. Time Dilation Inside Black Hole

So hypothetically if a watch could be sent to the Event Horizon and monitored. It would be seen that the watch is ticking slowly until it finally stops ticking as it reaches the Singularity. The Escape Velocity inside the event horizon exceeds the speed of light so not even light can escape from it. So, the experimental watch can never be recovered. The radius of the event horizon can be calculated by Schwarzschild Radius which is proportional to the mass of the collapsing star. So, if the star was 50 times the mass of sun the event horizon radius would be 150km.

If a hypothetical spaceship was built that could withstand extreme gravitational force and reach the Black Hole. Then what will the person in the spaceship feel and see and an observer in earth will see is extremely interesting to understand the time dilation concept.

So first understand what the person in the spaceship will see once the person approach near the event horizon of the Black Hole in the spaceship. Well the person will see that all events in the world happening extremely fast as if a fast-forward button has been pushed. The person will see generations change in a flash but for the person few minutes may have passed. If the spaceship does not fall into the event horizon then it accelerates and deflect away from the event horizon. In case it does not understand the point of event horizon and enters it then everything is lost as it will be pulled to the Black Hole Singularity. This feeling will not last too long though as once the person enters the event horizon the spaceship will be pulled extremely fast to the center of the black hole. Now the spaceship should fly in the opposite direction in speed exceeding the speed of light. The actual speed needed will be more than the speed of light and it is known that the maximum speed that can be attained in physics is the speed of light. At this point the person will not be able to understand what is going outside the event horizon due to extreme speed in which the spaceship will be nearing the Black Hole Singularity. If the spaceship survives and falls in one piece to center of the Black Hole which is again not possible as no matter can stand the gravitational pull there. Once the spaceship is inside the event horizon it should have been stretched like a spaghettification into pieces. This is call Spaghettification. Still for argument if it is taken that the person landed safely in the center of the black hole singularity it is still not known to science that what the person will see as he may be in another dimension in time and space as space time is now totally curved.

The person for sure will not age as time has stopped but what the person will experience cannot be deduced in this paper. Now on the other hand for the observer on earth in the beginning when the spaceship was nearing Event Horizon events will seem to slow down significantly and after a point of time once the space-ship has approached the event horizon the observer will feel that you it has stopped and frozen in space. Slowly the spaceship will fade away and another there will be need of few generations of observers as human life time has no significance to Universe Time. So, for the spaceship may be few hours have passed but for the observer several generations have passed. This is how peculiarly time gets dilated in a Black Hole.

C. Why is Black Hole, Black?

It is known that for anything to escape from earth that object needs a velocity that is equivalent to the escape velocity of earth. This theory is universal for any celestial body including Black Hole. So, if an object that has fallen into the Black Hole and wants to escape from it then the objects needs to attend the escape velocity which will be equivalent to the escape velocity of the Black Hole. Escape velocity is calculated by the following formula, where V_e stands for the escape velocity, G stands for gravitational constant and its value is $6.67 * 10^{-11} m^3 kg^{-1} s^{-2}$, M stands for the mass of the object and generally calculated in Kg, and r stands for the radius of the object and is denoted in Km or meter.

$$V_e = \sqrt{\frac{2GM}{r}}$$

If the Earth's Escape Velocity is calculated, as discussed

$$G=6.67 * 10^{-11} m^3 kg^{-1} s^{-2} = 6.67 * 10^{-20} km^3 kg^{-1} s^{-2}$$

It is known that the Mass of Earth or $M= 5.97 * 10^{24} kg$

It is known that the Radius of Earth or $r=6370 km$

Once the values are placed in the equation, equation, the equation stands as

$$V_e = \sqrt{\frac{2 * 6.67 * 10^{-20} * 5.97 * 10^{24}}{6370}}$$

Once calculated $V_e= 11.18 Km/s$

The Escape Velocity of earth stands at 11.18 km/sec which means if a spaceship can attain this velocity it will be able to cross the gravitational pull of the earth.

As we go on reducing the radius and increasing the Mass a point will be reached where the escape velocity will be equivalent to the speed of Light. If we go on further increasing the mass or reducing the radius the escape velocity needed will exceed the speed of light.

If the speed of Light is assumed as "C" and it is taken as the Escape Velocity then the above equation will stand like this.

$$V_e=C=\sqrt{\frac{2GM}{r}}$$

Or, $r = \frac{2GM}{c^2}$

This above equation is also known as the Schwarzschild Radius. This is the radius of the Black Hole as Light cannot escape from this radius. If light is taken outside the radius it

can escape but in this radius the light cannot escape. The reason being that at this radius light need escape velocity which is more than its own speed so it gets trapped. That is why we see Black Hole as Black.

So, in Black Hole $V_e > c$, where V_e is the escape velocity and c is the speed of light.

D. Light and Time

From the understanding of escape velocity and speed of light it is clear that once light enters Black Hole it gets trapped [11]. So, if lights get trapped does time also gets trapped. According to special relativity it is known that as we accelerate, we slowdown in time. In the earlier part of the paper it was discussed how time behaved for a person in spaceship in comparison to an observer on earth. So faster one moves is space the slower one moves in time. What about speed of light? As it is known speed of light is constant and for both the observer and the person on spaceship speed of light will remain the same that is 299792458 m/s. So, if speed of light is same everywhere is it same inside Black hole. The gravitational force may deviate the direction of light as it is observed through gravitational lensing but this does not reduce the speed of light.

It was seen in the above equation light cannot exit a Black Hole as the speed of light is less than the escape velocity needed to escape the Black Hole this does not mean that speed of light reduces in Black Hole as time reduces. It may be possible that the Black Hole is spinning at near the speed of light so the light inside the Black Hole is spinning at its own speed but cannot escape due to the escape velocity issue. So, time may be perspective to one another or in better worlds time may be relative to one another as described by Einstein in Special Relativity but speed of light is constant. Once inside the event horizon light has to travel to the central singularity and what happens after that remains a mystery.

E. Black Hole Singularity and Speed of Light and Time

Black Hole Singularity is a point of infinite mass and energy with zero volume the concept itself puzzles all universal laws of Physics [9]. Understanding what happens to time at this point cannot be definitely be said but it can be assumed that time slows down infinitely to a possible point zero if any. Similarly, space time curves in such a way that light itself gets distorted and may not have the same properties at it had outside a Black Hole [12]. Also, as it is not known what are the other Dimensions in Singularity (if any) so it would be hard to tell if light gets distorted to another dimension or another form. It may be that photons itself changes to some other form so we no longer see light inside the Black Hole. It may be a possibility that due to the immense gravitational pull photons change from. It is known that photons do not have mass but energy.

Now once it enters the singularity of Black Hole it would lose its kinetic energy and so it has to transform to another form of energy as it is known from first law of thermodynamics that energy is conserved. So, the energy photon was carrying has to be transformed to another form of energy that as of now it has not been discovered.



IV. LIMITATION

It is very difficult to gauge that what exactly goes inside a black hole as space and time dilation happens over there. Photons are bend because of the extensive gravitational pull as a result of which the scientist cannot see inside a black hole. Hence, scientist can only speculate about the black holes. Also, black hole is thought to have naked singularity which in itself puzzles many astronomers as it does not follow any known laws of physics or mathematics. In the present era we lack sufficient instruments which are essential for study the black hole and hence, it is extremely difficult to test out the hypothesis developed by the scientist.

V. CONCLUSION

It is clear from the facts that we know that Light and Time both gets deviated in the Black Hole and as Photons do not have the senses so for it time does not exist. So, Time and Light are two in-dependent entities and do not correlate. While time is perceived by one according to the position or motion but speed of light is uniform throughout. SO, one may age less in a planet with high gravitational force than one with weak gravitational force but speed of light in both the planets will remain the same. The paper also discussed why light cannot es-cape Black Hole as the escape velocity of Black Hole is greater than the speed of light.

Only one light enters a Black Hole all its properties seems to behave in peculiarity as space time bends. It is presumed in this paper that according to the law of thermodynamics energy cannot be created or destroyed but transform from one form to the other. So, the Kinetic Energy of photon that nullifies in Black Hole has to get transformed to an alternative energy that it not known off till now.

As the escape velocity of the Black Hole is more than the speed of light so light cannot escape the Black Hole but it gets transformed to another form of energy as it goes near the Singularity. Does it remain in the same dimension or crosses to another is another food for thought for further research?

This paper tried to understand the difference between time and light and their effect in front of Black Hole. The paper also tried to analyze how time will be different from one person to the other according to Einstein's theory of Social Relativity. The paper also showed a new energy may be created from Photon inside the Black Hole. The researchers hope that this paper will be useful for future researchers and one day the mystery energy that may be created by conversion of photon may be realized.

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