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Short Communication

Black Hole: Why we are not able to detect anything escaping it

Lipoknukshi Jamir
Nagaland, India
lipoknukshi.jamir@gmail.com

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Abstract

This paper is a theoretical approach, basing on Special and General Theory of Relativity, about why we cannot detect a particle (or an object) escaping a black hole and what will happen to it after escaping the gravitational field of the black hole. From Einstein's relativity we know that time is affected by both the speed at which an object is moving as well as gravity. The faster it moves the slower is the time; and the more the gravity the slower is the time. If we consider a spaceship moving around a black hole, then, from the ship's perspective time will be slowed down as compared to an observer on earth owing to the massive gravity of the black hole. In order to escape the black hole, the ship has to gain speed which will result in time to slow down further. Thus, the time elapsed for an observer onboard the ship will be much shorter as compared to an observer on earth. This will bring us to a point in time where the time difference between the two observers will be so large that the ship will be moved into the future and this point will appear as an illusion, to the observer on earth, as if the ship has been sucked in by the black hole. Thus, we cannot detect an object escaping a black hole because in reality it has travelled through time.

Keywords: Special relativity, general relativity, black hole, time-dilation, event horizon.

Introduction

Einstein's Theory of Relativity has revolutionized science and changed our perspective of how we perceived time and space[1]. The Special Theory of Relativity predicts how time is affected by the speed at which an object is moving[2]. This effect in time is known as time dilation[1]. It is a real effect and applies to time itself; slowing down all the biological processes – growth, aging and decay of living systems[3].

Also, General Relativity predicts that time is as well affected by the presence of gravitational field[3,4]. Accordingly, time will run slower under a strong gravitational field than under a weaker field[5,6].

General relatively clearly predicts why nothing can escape through a black hole[1]. However, we still don't have a clear understanding of what will happen to a particle or an object after crossing beyond the event horizon.

To answer this question, I have used the above predictions of Special and General Relativity arriving to a conclusion as to why we cannot detect anything leaving a black hole and what happens to anything escaping it.

Methodology

According to first postulate of special relativity, in all inertial frame of reference the laws of physics are to be the same[1,4,7]; and in accordance to second postulate, provided in free space, the speed of light is same in all inertial frames of reference[1,7,8].

Another interesting phenomenon arising out of special relativity is time dilation, the effect of which is that, a clock which is in motion will tick much slowly than a clock at rest[1,9].

Also, general relativity predicts that time is affected by gravity and this has found its application in the working of the Global Positioning System (GPS), where, each clock fitted to the satellite gain every day around a third of a nano second and this difference in time has to be correct by the system in order to avoid any catastrophic event[6,10].

These concepts and understanding of relativity are used in this paper to support my argument and come to a conclusion as to why we cannot detect anything escaping a black hole and what will happen to the object after escaping it.

Results and discussion

Why we cannot detect anything escaping a black hole: For simplicity, let us assume that we are on a space mission and have deployed a spaceship to a black hole and it has now reached the vicinity of the black hole. As the ship approaches closer to the black hole, the influence of its gravitational field increases, thereby, slowing down time for those onboard the ship in accordance with general relativity. To stay in orbit around the black hole, the ship has to increase its speed, thereby, slowing down time further in accordance with special relativity. Now for an observer inside the ship, the speed limit *c* (2.998 x 10^8 m/s) will not be violated as light itself will be affected by the gravity and thus the observer inside the ship will always measure the speed of light to be *c*. Moreover, in the vicinity of the black hole, time will be slowed down simultaneously for everything around it. Therefore, to the observer inside the ship, everything will appear to be normal.

Suppose, the dilation in time due to the black hole is $1/5^{th}$ of that on earth. This means that the crew members on board the ship will experience only 0.2 second for every 1 second of time elapsed on earth. This seems to be quite small and it seems nothing catastrophic will result out of it. But, in reality it will result to an unusual outcome.

If an observer from earth has measured that 1 hour of time has elapsed after the ship started to orbit the black hole, then only 12 minutes would have been experienced by the crew members onboard the ship. Now if the mission was to last for 5 years and assuming that the crew members have stayed in orbit for 5 years in accordance to their clock, then, for those on earth 25 years would have been elapsed. Now what could have happened between the years to those controlling the mission from earth?

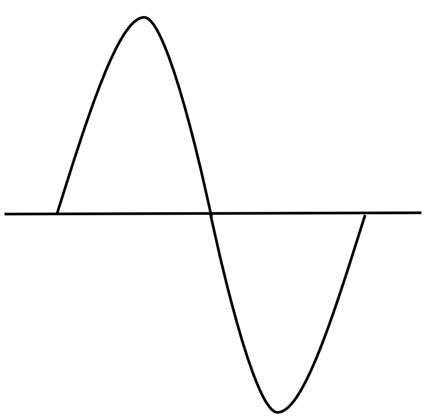
As the ship approaches closer to the black hole, the gravitational effect on it increases and thus, the ship has to increase its velocity accordingly so as to maintain its orbit around the black hole. This will seem quite normal to those onboard the ship as everything, including time, will be slowed down simultaneously. However, to those on earth, they will record this increase in velocity to be quite large and hence the ship will send out ripples of waves as it moves its way towards the black hole.

An interesting phenomenon which will result due to this is that, since time dilation affects everything, therefore, to an observer from earth, they will record the time period for the wave to have increased as compared to those onboard the ship (Figure-1). This relative increase in time period as well as in velocity will ultimately led to an increase in wavelength, when observed from earth, according to the relation $v\ T= \lambda$, where, v is the velocity, T the time period and λ is the wavelength. Thus, an observer from earth will record the wave to be shifted towards the red spectrum.

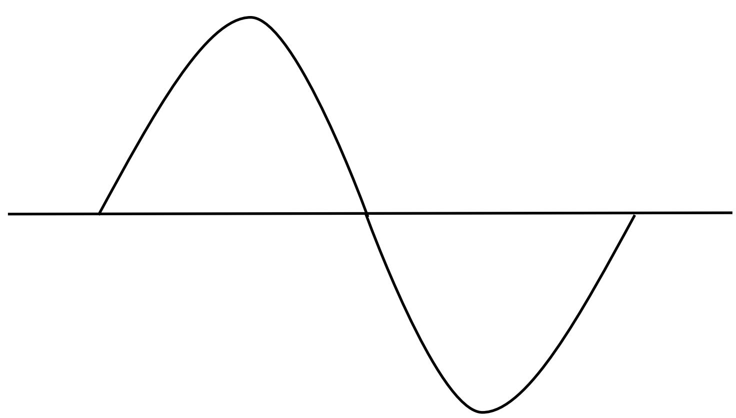
As the ship approaches towards the event horizon, it will have to maintain greater velocity as the gravitational field will tend to increase more, causing further dilation in time resulting in the wavelength to shift further towards the red. As such, a point arises where the dilation in time is so much that the wavelength is shifted beyond the red spectrum and hence, we will not be able to detect the ship and lost contact with it.

But what actually happens is that the time dilation at this point becomes too large that it reduces the time around the ship so much so that it causes considerable difference in time between those on earth and those onboard the ship thereby causing the ship to move in time towards the future. From earth, this point will appear as if the ship has been sucked in by the black hole and it gives the illusion of the event horizon beyond which nothing returns.

A hypothetical experiment: I would like to present a hypothetical experiment as to how to prove the above findings. If somehow, we could detect a particle moving around a black hole in the present time, analyse its data and calculate the possible dilation in time; and if in the near future (say after 5 years, or 25 or 100 years) it happens that we again could detect the same particle then there are possibilities that it might be the exact same particle which have been detected years back except that it has now re-appeared again in a different time-frame, or simply the future.



(a) Wave as observed from the spaceship



(b) Wave as observed from earth

Figure-1: The figures above show how the wavelength is stretched when observed from earth (b) as compared to an observer onboard the ship (a).

Conclusion

Einstein's relativity theory has changed the perspective of how we perceive time and space. It has paved ways for new areas of research in science. Through it we could understand how space, time and matter behaves around a black hole; how time is dilated by its gravitation field and the consequences of it.

If at all anything escapes from a black hole, then, we are not able to detect its escape because the black hole has an enormous gravitational field that it dilates time considerably and for the particle to overcome it, it has to gain enough velocity thereby dilating time further. Thus, the particle after escaping a black hole resurface itself in another time frame – The Future. Thus, we can conclude that the stars which we observe today as being sucked in by the black hole can actually be from the past which have travelled through time and there is even possibility that humankind will detect the same star revolving around the black hole in the near future as well.

Acknowledgement

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