Black Holes; Do they exist and if so what effect could they have on us?

Black Holes, a story for science fiction or is there truth behind their existence. These astrological anomalies are still a wonder to the greatest scientists in the world and not yet identified to truly exist. During this investigation I will be looking into the way in which ideas of Black Holes existence have developed over the years. Furthermore this investigation will also look into the ways in which a Black Hole can be identified and if so; what effects they would have on us.

First, the question of "What is a Black Hole" needs to be answered. In simple terms a Black Hole is a region of space that has so much mass concentrated in it that there is no way for a nearby object to escape its gravitational pull. Black Holes were once thought to be the monsters of the Universe, devouring everything around them in a frenzied cosmic feast. Black Holes are regions of space where gravity is so strong that not even light can escape, making them impossible to see. But we can see the debris that is being sucked in to these collapsed stars. Anything that approaches a Black Hole is first torn apart by it's immense gravitational force and then forms a flat rotating disc that spirals into the hole.

The name "Black Hole" was not developed until 1967 but ideas around their existence have existed since the 18th century. The first ideas were put forward in 1783 by Reverend John Michell where he talked of how "light could not escape from a star of the same mean density as the Sun but 500 times bigger". These first ideas on Black Holes were based around speculations about Black Holes hinged on ideas about the nature of light. By the end of the 1 7th century it was known that light travelled through space at a great speed. Then in 1965 Ole Romer made one of the first estimates at the speed of light after studying the path of one of Jupiter's moons. Then in the early 1900's Albert Einstein united the concepts of space and time; first discovered by Isaac Newton, with ideas of light itself. The result was that Einstein realised that space and time had to be dynamic entities that were themselves responsible for the force of gravity and this lead to his general theory of relativity. Black Holes however represent an extreme where gravity dominates and so space and time become distorted beyond recognition. The mathematical theory behind black holes (I shall explain this later) arises from Einstein's general theory of relativity, but the idea of an object from which light can not escape was first thought of in the 18^{th} century. When these ideas were stated by Michell (these are talked about at the beginning of the paragraph) it was generally held that light consisted of particles that travelled in straight lines through space. This idea arose from an interpretation of Newton's ideas. The consequence of Newton's laws of motion and gravitation had been studied exhaustively for a century and after much experimentation were deemed as being extremely accurate. Therefore towards the end of the 18^{th} century these laws were being applied to all situations whether astronomical or Earth bound. It was from this that Michell was able to predict that surely light particles would have the same forces of gravity acting upon them as would you or I and therefore they were not excluded from the laws of gravity. Therefore he predicted that an object could exist that had such a great gravitational pull that it would be greater than the speed of light and so nothing would be able to escape this object. The object was then later named a "black hole".

As Black Holes have not be proven their existence is only hypothetical and so we have to visualise them in our mind In order to identify "what is a Black Hole" we have to think about this in practical terms. This can be done by detailing the following scenario. Suppose that you are standing on the surface of a planet. You throw a rock straight up into the air. Assuming you don't throw it too hard, it will rise for a while, but eventually the acceleration due to the planet's gravity will make it start to fall down again. If you threw the rock hard enough, though, you could make it escape the planet's gravity entirely. It would keep on rising forever. The speed with which you need to throw the rock in order that it just barely escapes the planet's gravity is called the "escape velocity." As you would expect, the escape velocity depends on the mass of the planet: if the planet is extremely massive, then its gravity is very strong, and the escape velocity is high. A lighter planet would have a smaller escape velocity. The escape velocity also depends on how far you are from the planet's centre: the closer you are, the higher the escape velocity. Now imagine an object with such an enormous concentration of mass in such a small radius that its escape velocity was greater than the velocity of light. Then, since nothing can go faster than light, nothing can escape the object's gravitational field. Even a beam of light would be pulled back by gravity and would be unable to escape.

We know that stars do not exist for eternity and that once they have burned off their gasses will collapse. It is using this knowledge that we are able to predict the theory behind a Black Holes existence. This can be done by taking simple gravitational theory. We can predict the ideas of an impossible escape velocity in a situation where the mass of an object far larger than our Earth will collapse and concentrate all of its mass into one area; and mass is a key element into the potential gravity of an object. This idea is important as it backs up the theory of what a Black Hole is "a mass which will suck all matter around it, into its centre from which nothing can escape". This idea works as the gravitational pull of a Black Hole is stronger than the speed of light itself and as Einstein's law (E = mc) states; nothing can go quicker than the speed of light. The theory detailing how a Black Hole can potentially exist is detailed below.

The escape velocity from the surface of a massive spherical body is the minimum necessary speed an object needs in order to be launched into orbit from the surface of the object. Any speed slower than the escape velocity and gravity will eventually reduce the speed of the object until it falls back to the ground.

Escape velocity from an object of mass M can radius R can initially be calculated by considering the escaping objects energy. Initially, an object of mass m launched at speed v has kinetic energy of the value E, thus: $E = \frac{1}{2} mv$

As the object rises, it will slow down due the laws of friction and gravity acting upon it; therefore it must have just enough kinetic energy at take off in order to overcome these forces and still have a little energy in order to continue moving. When considering motion near the surface of the body the force of gravity ▲E gained when the object rises through a distance ▲r is given by the formula: ▲E = mg▲r

But as the object moves away from the body the forces of gravity acting upon it will decrease. We know that $g = \frac{GM}{R}$

Here r is the distance from the centre of the body and G is the universal gravitational constant. In order to find the overall change in energies the contributions from a sequence of small height increments each of ▲r need to be added together. This can be done using algebra giving the equations:

$$E = \int mgdr = \int \frac{GMm}{r} = \frac{GMm}{R}$$

In an interaction the total energy is always the same and be calculated by adding the kinetic energy and the potential energy; the two are proportional and so as one changes so does the other. At the point at which an object reaches the escape velocity the kinetic energy will become 0 and so we can combine the formula above to give: $\frac{1}{2} mv = \frac{GMm}{R}$

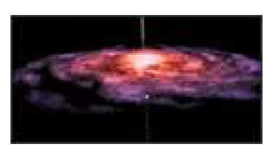
If we cancel m and rearrange the formula we can gain a formula which represents the velocity which an object will need to escape the body. The formula being:

$$v = \frac{2GMm}{R}$$

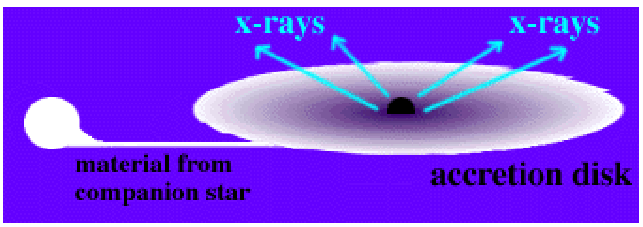
For the body to be a Black Hole v = or is greater than c and so the formula becomes:

$$c \geq \frac{2GMm}{R}$$

So the concept that Black Holes exist is there; but this is only theory so what physical proof is there that Black Holes actually exist. There are two such methods of finding black holes, one uses the detection x-rays and the other just the naked eye.

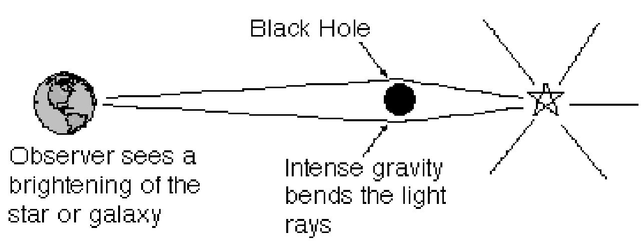


The first of these is the closest that scientists are to identifying the existence of black holes as until we can physically see them or create them for our selves we can only rely on the ideas of calculation and detection. The idea behind the detection of x-rays relies on the knowledge that a black hole (as we know them) will pull all matter around it into tits centre. Furthermore we know that stars sometimes come in binary pairs and the creation of a black holes relies on a star exploding and then collapsing. Therefore by using this knowledge scientists are able to look out for situations where black holes could occur. The situation being where one star is rotating around another; but one of the stars has changed into a back hole and so the result is that the remaining star is orbiting around the black hole; therefore it looks as if the star is rotating around nothing. Furthermore this situation is backed up by the fact that if such a situation does occur; then mass from the living star will be pulled away and into the black hole, leaving a trail of debris (an artists impression of this situation can be seen at the top of page 1). So a situation where there is a possibility for identification has been found but how can scientists actually use this occurrence to predict that black holes could exist, as if even if they have found somewhere where they could exist, Black Holes still can not be seen. The answer is x-rays. We know that matter from the living star in the binary pair is sucked off of the black hole and forms an "accretion disk" of matter which will rotate around the black hole until it reaches the centre



(similar to the way in which the water will flow down a plug hole). The matter in the accretion disk gets very hot as it falls closer and closer to the Black Hole, and it emits large amounts of radiation, mostly in the X-ray part of the spectrum. Therefore this indicates the potential existence for a black hole. Furthermore in this situation simple calculation around the mass and speed of orbit can also help identify the existence of a black hole. This can be done by measuring the orbital speed of the visible star from which the mass of the invisible black hole can be determined. If the mass of the supposed black is found to be very large very large, then there is no other kind of object we know of that it could be other than a Black Hole. So it is an art of illimination as an ordinary star of that mass would be visible.

A simpler method of identifying the possible existence of a black hole is using Albert Einstein's knowledge that light follows in the path of the bent time and space which is altered due to the gravitational force of a massive object (in this case a black hole). He predicted that a star positioned behind an object such as the sun would still be visible during a total eclipse as the sun would bend the light rays coming from the star. This idea can be used in the identification of a black hole through a technique known as "gravity lensing". This methods works as when a large object (such as a black hole) moves between a star and the Earth the object acts like a lens and focuses light rays from the star on the Earth; causing the light to brighten. This situation is identified in the diagram below.



Now that scientists are able to identify the possible existence of a black hole what possible effects could they have on us? As we know it, Black Holes will currently have no effect upon us as we are to far away; although one idea is that a black hole a the centre of universe is what could have potentially attracted all of its mass. If you were to get close to a Black Hole however, at first, you would not feel any gravitational forces at all. As you get closer and closer to the centre of the Black Hole, though, you would start to feel "tidal" gravitational forces acting upon you. These have been named “tidal” gravitational forces as this force acts in the same way as the forces that cause tides on earth act. The effect of these tidal forces would create the following situation; imagine that your feet are closer to the centre than your head. The gravitational pull gets stronger as you get closer to the centre of the hole, so your feet feel a stronger pull than your head does. This situation occurs near a Black Hole due the vast gravitational pull that is created. The effect is the same as on Earth, for example there are less forces of gravity acting on you at the top of a mountain than there are at the bottom. But on Earth these differences in strength have little effect, as they are so small in comparison. As a result of these “tidal” gravitational forces you feel "stretched." These forces get more and more intense as you get closer to the centre, and eventually they will rip you apart. Therefore the experience of entering a black hole would be short lived and you would not be able to tell the tale, as a). you would be dead and b). you would not be able to escape from the black hole to tell the tale!

If you were able to live through entering a black hole though you would see images of faraway objects as all light would be sucked into the black hole. But these images would be distorted in strange ways, since the Black Hole's gravity bends light, apart from this and other debris that has been sucked in with you there will be very little to see. Even though light can not escape from a black hole (and so they can not be seen); light from the outside can still be seen. It is from these ideas that some predictions state that upon entering a Black Hole; time would be distorted and potentially you could view the end of the world as all light is sucked into the Black Hole.

Black Holes are still a mystery and are on the for front of modern astrological science. Many questions still need to be answered around if they truly do exist or if they are just myths (in the same way that once we believed the world to be flat!) Until we experience a black hole however we may never be able to answer these questions; but by then it could be too late!