# The problem with Black Holes

Ramblings of a layman



It seems to me that the most prevalent description of a Black Hole (paraphrased) is "a region of space where the gravity is so great that nothing can escape, not even light." Lately, it has become popular to add "infinitely small" to the beginning of that definition. As a nonprofessional, I have real problems with looking at Black Holes in the purely mathematical sense that would permit this definition! In fact, even if capable of mathematical understanding, I would still see great problems with this definition. The "infinitely small" part really seems improbable.

**Infinitely Large.** To me, "Infinitely Large" is somewhat understandable. What do I mean by this? As a small boy, I asked my father the question: "How high is up?" His answer explained infinitely large in a way that I understand. He said: "If you were to follow a perfectly straight line forever, you would never get to the end of space (up). Cosmologists would probably dispute this by saying the universe is curved or that nothing has meaning without including time in the discussion, but please put that aside for the moment. If it is possible to continue in a perfectly straight line forever, and the starting point is thought of as the center of a sphere, it follows that the sphere is infinitely large. In other words, on the outside of space (the universe or universes), there is just more space! No matter what Hawkings and Einstein taught us about time, and the space-time continuum, there is no end to space. There surely is an end to our universe as the big bang theory predicts, and there could be many more universes, but what's outside that? You can absolutely say more space! Even if there are an infinite number of universes, or dimensions, or some undiscovered state, the fact remains that outside it all; there is more space (or nothingness)!

**Infinitely Small.** To me, "Infinitely Small" is only a mathematical curiosity. I can think of no example of anything that is infinitely small. For instance, think about temperature. We know what absolute zero is – the absence of heat. Not an infinitely small amount of heat – the total absence of heat. Given enough energy, there probably is no absolute high temperature – temperature can be infinitely high! Cosmologists talk about particles so small that they call them massless, but even they are not infinitely small. Cosmologists don't really say that they are so small that they are massless, they say that certain energy acts sometimes as waves and sometimes as particles and that they are therefore massless. Well! That makes it even easier to understand. A wave can be "cut" in half by doubling its frequency! One last way to look at it is that given any size, and a small enough "knife", you can cut a particle in half; so how can anything be infinitely small?

While this line of thinking seems to have no real value, think about this. We read often that such and such is so dense that a teaspoonful will weigh more than the Earth. How could that be? There's only one way! The space between the parts of the matter itself is squeezed to an unimaginable extent. In other words, the space between the atoms is reduced. For instance, a container of compressed pure oxygen if released into container twice the size of the original that has been completely evacuated will contain only oxygen, but the atoms will have twice as much space between them. If the oxygen is in the $O_2$ form the molecules will have more distance between them, and the atoms of the molecules will maintain their distance within the molecule. What gets interesting is this: What happens when you compress the molecules so much that the distance between the atoms of the molecules is reduced? Can you compress them enough that the orbiting electrons of the atoms collide? Can you compress them enough to make new molecules ($O_3$, $O_4$, etc.) Can you compress the components of the atoms enough to make new elements? We know you can up to a point – that's what fusion in stars does all the time!

**What is a Black Hole?** A Black Hole is a star! OK, it's a massive star. In fact, it is so massive that its gravity doesn't let anything escape, not even light. The term massive is a problem for nonprofessionals. For instance, when a star like ours grows old (uses up its nuclear fuel), it can become a Red Giant. A Red Giant, from the standpoint of its diameter, is much more massive than our star and probably more massive than most Black Holes. The "massive" of stars and Black Holes is massive as in with great mass – not size. So, let's try again at a definition.

***A Black Hole is a star with a mass so great its gravity prevents the escape of everything.***

Now that is more believable, at least to me! Notice that the definition could represent a Black Hole with a small diameter, or one with a very large diameter. Also, in his later years, Hawking started that there is an energy escape from Black Holes and that over a long enough time they would evaporate – given our capability today to somewhat image them, this seems true so one more stab at a definition.

***A Black Hole is a star with a mass so great its gravity prevents the escape of everything except possibly energy.***

**What is Gravity?** Gravity is a force that is not well understood, but some of its properties are well defined.

1) Gravity is additive in all directions, gravity is not polarized, and gravity increases as mass increases. In other words, any two bodies pull on each other no matter how small they are or how they are oriented.
2) Gravity works over long distances, but its intrinsic strength is small. For instance, when astronauts go into space, they become nearly weightless. However, the moon is much farther from Earth than the space shuttle in orbit, and it is certainly not weightless, and its gravity pulls on the Earth causing tides in the ocean and other effects. By the way, here's something else to consider. I said that astronauts become nearly weightless. That's not even close to true! The space shuttle does not venture very far from Earth. The astronauts seem to be weightless only because they are continually falling towards Earth. In fact, gravity is still rather great while they are in orbit and therefore, they still have most of their weight!
3) The more mass an object has the more gravitational pull it exerts on other objects. For instance, the Sun's mass is much greater than all the planets and that gives it the strength to keep all the planets in orbit. If it were not for gravity, each planet would be moving through space in a more or less straight line (if they existed at all). In the same way, the moon is held in Earth's orbit by the gravitational pull of the Earth (and Moon).
4) Gravity can attract light as if light were made of matter. When a beam of light passes a strong gravitational field, the beam of light is bent. This has been proven experimentally. However, it is not apparent that light itself has gravitational pull. Light is one of those things that is sometimes considered a wave and sometimes a particle. As a particle, it would have to exert gravity, but as a wave, it would not. Now, if we could just find a way to pass two beams of light past each other without any outside gravity, we could see if light exerts gravity and thereby prove whether light has mass. Maybe someday we can make much better

lasers than today and send two parallel beams to a receiver on the moon. If the beams converge at all due to being next to each other, we will know that light has gravity. Of course, there would be so many outside influences between the Earth and Moon that the experiment would be difficult to set up and prove. In addition, even the best lasers today don't make a beam of light that stays the same width when beamed from the Earth to the Moon so a major correction for that would be needed.

So let's try a definition of gravity that we can use in our discussion of Black Holes.

***Gravity is an intrinsically weak force that is attractive in all directions, is additive between bodies, and increases in strength as the mass of the matter generating the force increases.***

**How "big" is a Black Hole?** This is quite a contentious question! Generally, a Black Hole is said to be no larger in radius than described by the formula $R = GM/c^2$ where G is a constant known as the universal constant of gravitation, M is the mass of the Black Hole, and c is the speed of light. This radius is called the [1]Schwarzschild Radius after the German astronomer Karl Schwarzschild, who derived the first model of a black hole in 1916. The Schwarzschild radius of a black hole marks its *event horizon,* or the boundary past which light can enter but not escape. Many astronomers and cosmologists believe that once an object collapses to within its Schwarzschild radius, it continues collapsing until it becomes a singularity or a point with infinite density and a radius of zero. Hello! I don't think so! That works on a chalkboard but defies simple logic! You might as well say: "1 = 0". In other words, to say that something is nothing just does not work!

The sun has a mass of $2\times10^{30}$ kg and a radius of about 700,000 km. Its Schwarzschild radius is about 3 km. If the sun were to collapse into a sphere with a radius of less than 3 km, light from the sun would be trapped and the sun would become a black hole. The sun, however, is not massive enough for it to collapse to this size and become a black hole. Later, I may try to convince you that the Sun might contain a Black Hole and that all stars could! Don't worry, I won't try hard!

**Does a Black Hole Grow, Shrink, or Remain Stable?** When a Black Hole forms, regardless of its initial size, if matter falls into it, it grows. How can I say that so matter-of-factly? No matter how compressed the matter of the Black Hole is, more of it must make it larger – absolutely from a mass standpoint and most likely from a diameter standpoint. Still, lately I have read that some believe that as matter falls into a Black Hole, that the diameter becomes smaller as the pull of gravity increases due to the increase of matter.

Since a Black Hole is still a star, it continues to use its fuel. Therefore, Black Holes that are not "feeding" must be shrinking. The biggest question is do they quit being Black Holes after shrinking to some point, or do they continue shrinking until they evaporate? I suspect that they quit being Black Holes and become some form of "normal" star again. Thinking of the formula for the Schwarzschild Radius again, if the mass goes up, so does the radius. This is true unless you believe in the notion that a star can shrink to zero size, which invalidates the Schwarzschild Radius formula we used to determine the radius of the Black hole to start with! Also, there's the pesky Hawking thinking about Black Holes evaporating over time.

---

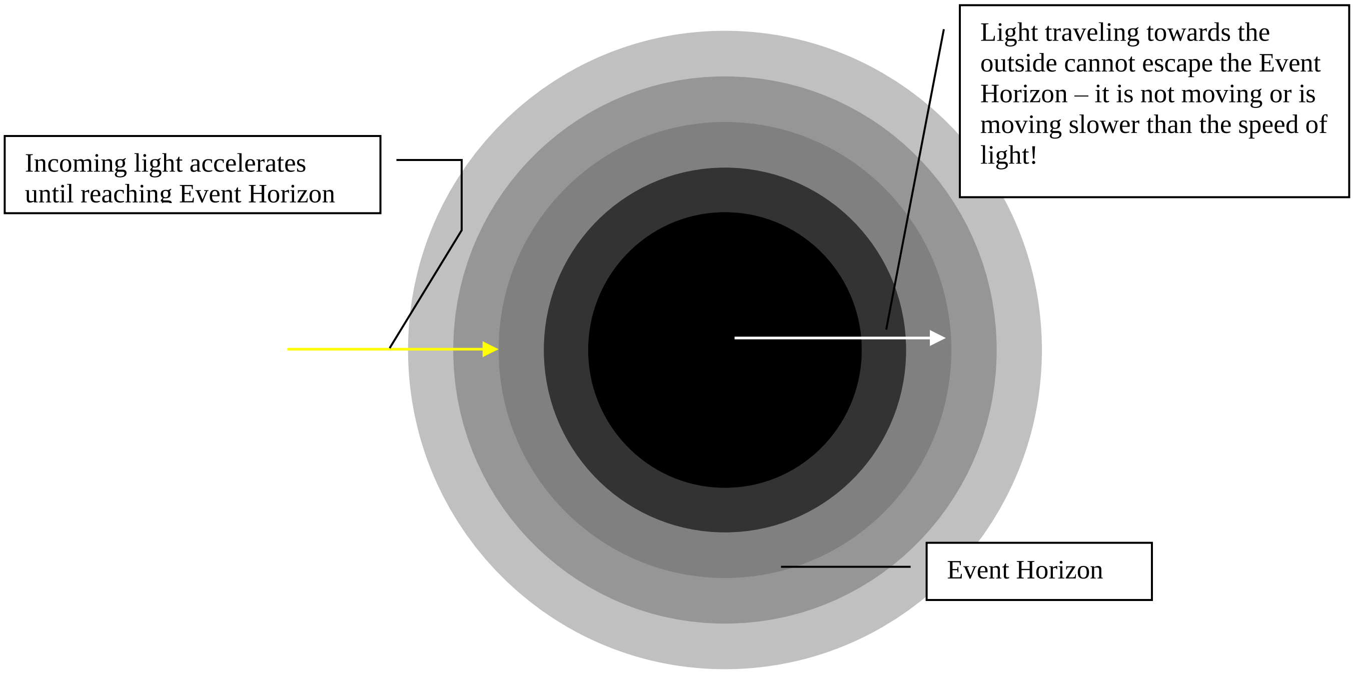
[1] "Schwarzschild Radius," *Microsoft® Encarta® 98 Encyclopedia.* © 1993-1997 Microsoft Corporation. All rights reserved.

**What shape is a Black Hole?** I keep using the terms radius and diameter like a Black Hole is a sphere. A Black Hole is so close to a perfect sphere that I choose to think of one that way. Our sun is very nearly a sphere due to its gravity, but it is not a perfect sphere. The tug of the planets, the sun's spin and movement through space, sunspots, and so forth all change the shape of the sun somewhat. A Black Hole's gravity is so great that it is pulled much more reliably into a sphere. Still, if a Black Hole gobbled up our sun, for at least some time, there would be fluctuations in the shape of the Black Hole. For the moment, we'll table the other possibilities like what if two Black Holes are near enough to each other to significantly feel their mutual gravity?

**So now, we come to the crux of the problem with Black Holes.** Where in the matter of a star is the actual Black Hole? Very generally speaking, a star has a core, a region that is fusing lighter elements into heavier ones, and an "atmosphere" (corona). This is much like Earth that has a solid (probably molten) iron core, a mantel, and an atmosphere.

**Let say we have a star that is just short of enough mass to be a Black Hole:** Since gravity is additive and works in all directions, doesn't it stand to reason that the center of the star would already be a Black Hole if the star overall has almost enough mass to become a Black Hole? At first thought, it seems so; however, maybe not. Since gravity is additive, maybe Black Holes have centers that are not like the outer portion of the Black Hole, maybe the center of Black Holes is even non-existent! In other words, a Black Hole may be a star with a hollow core and the size of the hollow portion depends on the overall diameter of the star and the density of the matter that initially makes up the star. In fact, it may be that only a small percentage of the star, its outer shell, is "black". Cosmologists seem to think that the basic composition of matter changes somehow to allow all the components of matter to become closer together and therefore to compress the mass into a smaller area. If true, the heart of a Black Hole is denser than the outer portions. If not true, the gravity in the center of a Black Hole is insufficient to qualify as the area as "Black".

**For my purposes, it doesn't really matter!** The one thing that is clear is that once in the Black portion of a Black Hole, and travelling away from the center, the mass and therefore the gravity becomes less. To prove this, think about the outer edge of the Black Hole. The matter of this outer edge "feels" the effect of the matter inside the Black Hole, but there is essentially no pull from the outside of the Black Hole. This variation exists throughout the "Black" part of the star or at least to the mass-center of the black part in the case of hollow Black Holes.




In this simple illustration, consider the centermost portion to be certainly in the “black” portion of the Black Hole, the next ring to be still black, but with less pull from the outer areas than from the inner, and the third ring to be the end of the “black” portion. Notice that the light (white arrow) stays within these three rings but that the star’s area is larger that the “black” portion. Also, notice that the light approaching the “black” portion of the Black Hole disappears when it reaches the event horizon (when viewed from the outside).

One very interesting thing about this scenario is that this Black Hole would not appear black at all. It would appear to be a normal star, a very big one, but a normal star! There really is no escaping the fact that the very nature of a Black Hole is to attract all matter and light in its vicinity. Since at any given time all of that matter and light has not passed the event horizon, the portion outside the event horizon is normal star “stuff”.

Another very interesting possibility is that “light” has no meaning inside the “black” portion of a Black Hole. If you were able to go inside, would there be any light? If so, what would its speed be? Certainly, light approaching the Event Horizon from the inside would have a speed lower than the escape velocity of a Black Hole, otherwise, it would escape and if it escapes, it would be traveling at the speed of light!

One last interesting observation about the interior of a Black Hole: What would be the condition of in falling matter? One theory is that if you were to jump into a Black Hole, your feet would feel the pull before your head, and you would be stretched to oblivion. I doubt it! The pull of gravity might be somewhat different on your feet and head, as it is on Earth, but the difference would still be miniscule! Remember that you would be travelling at nearly the speed of light. Still, surviving an encounter with a Black Hole would be difficult. The blood in your head would weigh more than the water in all of the Atlantic Ocean and your neck couldn’t support the weight!

The outer edge of a Black Hole is normally called the event horizon. Cosmologists often say that when information that is approaching a Black Hole crosses the event horizon, it disappears forever. This includes all energy and matter. For instance, if you could get near enough to a Black Hole to see the curve of its event horizon, and a friend would shine a light directly at the Black Hole, you would see the light beam up to the event horizon. What is more interesting is what would happen to the light just before the actual event horizon. If Einstein's General Relativity were correct with regards Black Holes, the light would look the same until it disappeared at the event horizon. However, logic dictates that there is a problem with that. If the gravity of a Black Hole is great enough to stop light from escaping; obviously, it must pull on the light with a force equal to or greater than the intrinsic force propelling the light. Such a force when pulling on approaching light should speed the light up to nearly twice its normal speed (OK, I know that's making people say I'm crazy). Matter is a different story. General Relativity says that to exceed the speed of light, the mass of an object would have to become infinitely large – which is impossible. Matter approaching a Black Hole would experience increasing pull the closer it got, but it's mass certainly would not become infinitely large – even the universe is not infinitely large

First year physics students learn that falling objects on Earth accelerate at a rate of about 32 feet per second per second until they reach terminal velocity. In other words, after the first second, an object is moving at 32 feet per second and after the second, the object is moving 64 feet per second, and so on. This goes on until the object is going about 194 feet per second. If the gravity of Earth were higher, the speeds would be higher. The same basic formula would work for a Black Hole, but the numbers would be much higher.

Due to gravity, just inside the event horizon of a Black Hole, the speed of light is zero or a negative number in an outward direction. What is the speed within the black portion of a Black Hole? I don't know. That depends on the gravity effect in any given area and in the direction the light is traveling. In other words, it depends on your frame of reference. Why bother with these statements? They seem to suggest that the speed of light is variable, at least within Black Holes. If the speed of light is variable within a Black Hole, how can we be sure it is not outside a Black Hole? Yes, this is a stretch, but something must give if we are ever to really explore this universe and gain real knowledge of these things! Of course, it is a well-known fact that the speed of light is different in different mediums, but the difference is slight. The difference I'm speaking of is not slight!

If we trust that General Relativity is correct, given a massive enough Black Hole, it follows that terminal velocity when heading directly for the Black Hole, on the boundary of the event horizon, is the speed of light or slightly (insignificantly) less than the speed of light. This means that matter approaching a Black Hole is moving at or just under the speed of light. It is normally said that matter cannot move at the speed of light and certainly not faster than the speed of light since the energy required would be infinite. The famous formula $E=MC^2$ states that mathematically. However, does it really? Since the energy involved is the pull of gravity, and we are assuming that it is great enough to produce a terminal velocity of the speed of light, I'll assign the energy variable (E) a value of 1. Now the formula says that the mass grows as the object speeds up, but it does not say that the mass becomes infinite. This is a convenient mathematical trick that has no logical meaning! The mass of an object does not change unless some outside force adds or removes matter. Matter is not added or removed by moving, no matter what the speed. OK, let's try it another way. Since the speed of light is considered a constant, and the mass of an object is not variable, let's let the energy vary and see what happens.  I'll assign a value of one to the mass variable (M).  This means that the energy required to move any mass is the square of the speed of light.  This also has little useful meaning --it's sort of like saying that one apple plus one pear and one banana is fruit – so what! Therefore, using Einstein's famous formula $E=MC^2$, at least when describing matter falling into a Black Holes is a problem!  Since matter falls into the Black Holes all the time and obviously does not approach infinite mass, General Relativity is incorrect near a Black Hole!  In addition, since matter falling into a Black Hole is traveling at or nearly at the speed of light, light speed or at least near light speed travel is possible!

Wow!  Did I just write that?  Yes, I did!  Logic is fun – hope mine is right!