DOWNLOAD PDF THE PULLING POWER OF A BLACK HOLE

Chapter 1 : BBC - Earth - The strange fate of a person falling into a black hole

What REALLY happens around a black hole: Psychedelic animation reveals the power of their gravitational pull. Researchers have never been able to observe a black hole with a telescope.

Why do some stars end up as black holes? The answer involves the gravity and the internal pressure within the star. When these two are balanced i. Such is the case for the Sun at the moment, and even, for that matter, for the Earth. However, when a star runs out of nuclear fuel, and therefore continues to lose energy from the surface it is emitting light energy , while not replacing the lost energy through nuclear fusion no more nuclear fuel , gravity will win out over internal pressure and the star will contract slowly or collapse quickly depending upon the details of the internal structure and composition. Gravity wins out over the internal pressure of the star, because that pressure was produced by a normal, hot gas, and that gas is losing energy as the star radiates energy from the surface. The star may thus end up as a black hole. It just depends upon whether or not the collapse is stopped at some smaller size once another source of pressure other than what is produced by a normal, hot gas can become sufficiently strong to balance the inward gravitational force. There are other forms of pressure besides that produced by a hot gas. Pressing your hand upon a desk top will let you experience one of these other pressures the desk pushes up against you, indeed it can support your weight gravitational force! The pressure that keeps the desk rigid against your weight is caused by forces between the atoms in the desk. Furthermore, electrons within atoms must avoid each other for example, they cannot all be in the same atomic "orbit" this is called "the exclusion principle". Therefore, if we had a collection of freely moving electrons they would also avoid each other: This "electron avoidance" pressure can only become strong enough to oppose the gravitational forces within a star of about the mass of the Sun when the star is compressed by gravity to about the diameter of the Earth. Thus a star as massive as the Sun can be prevented from becoming a black hole when it collapses to the size of the Earth, and the internal "electron avoidance" pressure called the "degenerate electron pressure" becomes strong enough to hold the star up. This sort of pressure does not depend upon the energy content of the star even if the star continues to lose energy from its surface, the pressure will continue to hold the star up. Our Sun can never become a black hole. However, if the star is more massive than something like 3 to 5 solar masses, its gravitational forces will be larger, and its internal degenerate electron pressure will never be sufficient to stop its collapse. It turns out that neutrons can also obey the exclusion principle and neutrons will be produced in abundance when a massive star collpses, but even neutron degeneracy cannot stop the collapse of massive stars anything over 3 to 5 solar masses cannot be stopped, it will become a black hole according to current thinking. How is time changed in a black hole? Well, in a certain sense it is not changed at all. If you were to enter a black hole, you would find you watch ticking along at the same rate as it always had assuming both you and the watch survived the passage into the black hole. However, you would quickly fall toward the center where you would be killed by enormous tidal forces e. Although your watch as seen by you would not change its ticking rate, just as in special relativity if you know anything about that , someone else would see a different ticking rate on your watch than the usual, and you would see their watch to be ticking at a different than normal rate. For example, if you were to station yourself just outside a black hole, while you would find your own watch ticking at the normal rate, you would see the watch of a friend at great distance from the hole to be ticking at a much faster rate than yours. That friend would see his own watch ticking at a normal rate, but see your watch to be ticking at a much slower rate. Thus if you stayed just outside the black hole for a while, then went back to join your friend, you would find that the friend had aged more than you had during your separation. In the case of a black hole, for instance, there has been some speculation that black holes can, through a quantum mechanical trick, radiate energy, and in the process their mass would therefore decrease. If nothing travels at the speed of light, except light, how can a black hole also pull light into itself? The path that a light ray follows can be bent by a gravitating body, even the Earth although the bending in that case is very small. This effect has been measured for light from a star as it passed the Sun during a solar eclipse. This bending of the light rays increases as the strength of the gravitational field increases. A black hole is simply a region where the effect on light is so great that light cannot escape the region. What is the best evidence for the existence of black holes? Is it all really just a theory? Astronomers have found a half-dozen or so binary star systems two stars orbiting each other where one of the stars is invisible, yet must be there since it pulls with enough gravitational force on the other visible star to make that star orbit around their common center of gravity AND the mass of the invisible star is considerably greater than 3 to 5 solar masses. Therefore these invisible stars are thought to be good candidate black holes. There is also evidence that supermassive black holes about 1 billion solar masses exist at the centers of many galaxies and quasars. In this latter case other explanations of the output of energy by quasars are not as good as the explanation using a supermassive black hole. You see, when matter falls in a gravitational field, its speed and therefore energy, increases. If lots of matter is falling in at the same time, and swirling around the black hole in a disk resembling a traffic jam in a cul-de-sac, then friction between the various pieces of matter will turn much of that speed-energy picked up during the fall into heat, which than gets radiated away. In this way, the matter surrounding a supermassive black hole can radiate more energy per gram of fuel than can be released by any other mechanism we know, including nuclear fusion. What does that mean and why does that happen? They may be referring to what happens as material falls into a black hole through the action of an accretion disk. As large amounts of material approach a black hole, the material will generally find itself in an orbiting disk-like structure with the hole at the center i. The disk will be extremely hot due to the friction between material with different orbital speeds at slightly different orbital radii. Thus the disk will radiate much light. Much of the incoming kinetic energy of the material is radiated away through this friction-heat-light process. This is what gives rise to the extreme brightness of quasars, and this process is what makes us able to possibly find stellar-mass black holes that are part of a double star system. In the latter case, infalling material from the neighbor star makes for the accretion disk around the black hole, and X-rays are emitted by the disk X-rays are emitted by extremely hot matter, just like the not-so-hot filament of a light bulb emits visible light. In the quasar case, a supermassive black hole a billion solar masses or so lies at the center of a galaxy, and gas near the black hole forms an accretion disk around the hole; again X-rays, and other forms of light, are the result. Nothing can escape from beneath the event horizon. Can you see a black hole? What does a black hole look like? Nothing, not even light can escape from a black hole. On the other hand, you can see some of the fireworks going on near a black hole. As gas falls into a black hole perhaps coming from a nearby star , the gas will heat up and glow, becoming visible. Typically, not only visible light, but also more energetic photons like X-rays will be emitted by the gas. What we would expect to see if our telescopes could "zoom-in" enough would be a glowing rotating disk of material, with the black hole down a the center of the disk. See the above answers. How big can a black hole get? There is no limit to how large a black hole can be. However, the largest blackholes we think are in existence are at the centers of many galaxies, and have masses equivalent to about a billion suns i. Their radii would be a considerable fraction of the radius of our solar system. How small can a black hole get? According to General Relativity the theory that predicts, and explains most of the features of black holes , there is no lower limit to the size of a black hole. But, a full theory of how gravity works must also include quantum mechanics, and such a theory has yet to be constructed. Some hints from recent work on this theory suggest that a black hole can be no smaller than about "to-the- " cm in radius 0. On that small a size scale, even the apparently smooth nature of space will break down into a "rat-trap" of tunnels, loops, and other interwoven structures! In short, the degenerate electron pressure in the star depends upon the density of the gas in a specific way that has no direct dependence upon how gravity and density are related. This power is determined by the properties of quantum mechanics and has nothing to do with gravity. The normal presentation of these gravitational time dilation effects can lead one to a mistaken conclusion. But if A falls down toward the event horizon eventually crossing it while B remains stationary, then what each sees is not as straight forward as the above situation suggests. As B sees things: Thus, A appears to freeze, as seen by B, just as you say. However, A has crossed the event horizon! It is only an illusion literally an "optical" illusion that makes B think A never crosses the horizon. As A sees things: A falls, and crosses the horizon in perhaps a very short time. If you wish, you can think of this as due to a cancellation of the gravitational time dilation by a doppler effect due to the motion of A away from B. A finite number of photons were emitted by A before A crossed the horizon, and a finite number of photons were emitted by B and collected by A before A crossed the horizon. You might ask What if A were to be lowered ever so slowly toward the event horizon? Yes, then the doppler effect would not come into play, UNTIL, at some practical limit, A got too close to the horizon and would not be able to keep from falling in. Of course, if A "hung on" long enough before actually falling in, then A might see the future course of the universe. Black holes can exist without being part of the final big crunch, and matter can fall into black holes. Black Holes and Time Warps. Could black holes be used as an energy source? There a great deal of information on the potential use of a black hole as a source of energy. Of course, it should be mentioned that one must first acquire a black hole! At least in the case of the Sun, we already have the Sun! I suggest you consult it for "all the information [I] could possibly give" you. In brief, a rotating black hole can store a huge amount of energy in its rotation. This energy is actually accessible since the rotation is imposed on the space outside the hole. In principle, therefore, energy can be extracted from the rotation of the black hole. Exactly what mechanism is used is a potentially complicated story. I read somewhere that in the VERY distant future black holes could leak and disperse. If it can, how? As yoy probably know, any object falling into a black hole cannot get out. However, over a very long time, particles of matter "leak" out of a black hole.

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Chapter 2 : Frequently Asked Questions About Black Holes

The pulling power of a black hole is all down to the size of the star's core as well as the mass. Black holes form in the core of a massive star, which runs out of fuel and collapses, exploding as a supernova.

Document download October 23, Scientists for the first time have seen energy being extracted from a black hole. Like an electric dynamo, this black hole spins and pumps energy out through cable-like magnetic field lines into the chaotic gas whipping around it, making the gas -- already infernally hot from the sheer force of crushing gravity -- even hotter. The observation also may explain the origin of particle jets in quasars. A supermassive black hole contains the mass of millions to billions of Suns compressed within a region smaller than our solar system. The black hole in MCG, over million light-years from Earth, has the mass of about million Suns. The team observed the X-ray glow of iron gas traveling about half the speed of light very close to the event horizon of the black hole in MCG an "event horizon" is the theoretical border of a black hole. XMM-Newton captured the spectrum, or chemical fingerprint, of this gas. The spectrum, laid out on a graph, resembles an electrocardiogram with its spikes and dips. Two spectral lines are present at 6. The broad yellow line is the new mystery feature fully revealed by XMM-Newton. Image courtesy XMM-Newton mission. The iron spectrum from MCG has extremely broad "spikes," an indication of gravity tugging at the particles of light, called photons, and literally stretching the light. The total energy output, or luminosity indicated by the spectrum, however, was too bright to be powered by gravity and the free fall of matter alone. Some additional power source must exist to boost the luminosity to the observed intensity. Co-author Mitchell Begelman of the University of Colorado said this finding may be observational evidence of a theory by Professor Roger Blandford, currently at the California Institute of Technology, and Dr. Roman Znajek, when he was at Cambridge University in England, over 25 years ago. According to the theory, rotational energy can be extracted from the black hole as it is braked by magnetic fields. Begelman said the energy lost in MCG is transferred to the inner edge of the accretion disk, a flow of gas swirling around and eventually falling into the black hole. The Blandford-Znajek theory implies that energy flows to particle jets emanating perpendicularly from the accretion disk in certain supermassive black hole systems called quasars. MCG is not a quasar, but Begelman said the theory can still apply because it predicts that the magnetic field might also link to the disk. ASCA, a Japanese X-ray satellite, found possible evidence of a spinning black hole in , but the signal was too weak to observe any evidence of energy being extracted from the black hole. The emission line is extremely broad, with a width indicating velocities of order one-third of the speed of light. XMM-Newton, launched from French Guiana by ESA in December , carries three advanced X-ray telescopes with the light-collecting ability to detect millions of sources, far greater than any previous X-ray mission. The advanced X-ray observing abilities of this satellite made this important discovery about the energy dynamics of black holes possible, and should lead to other exciting discoveries about our cosmos in the future. Web Links Black hole monster in a spin releases energy! Science NASA articles about black holes: A Monster in the Middle -- The Chandra X-ray Observatory may have spied a supermassive black hole in the center of the Milky Way Galaxy Cosmic Bar Codes -- The Chanda X-ray Observatory has peered into the nucleus of a distant galaxy and detected warm gas flowing away from a black hole. Measuring Spinning Black Holes -- Using data from several NASA satellites, scientists have measured the spins of several black holes, by accurately measuring the size of the last stable orbit of material around the black hole. Join our growing list of subscribers - sign up for our express news delivery and you will receive a mail message every time we post a new story!!!

Chapter 3 : A Black Hole Is Not a Hole - Carolyn Cinami DeCristofano - Google Books

Black holes are some of the strangest and most fascinating objects found in outer space. They are objects of extreme density, with such strong gravitational attraction that even light cannot.

October 19, They are objects of extreme density, with such strong gravitational attraction that even light cannot escape from their grasp if it comes near enough. Albert Einstein first predicted black holes in with his general theory of relativity. The term "black hole" was coined in by American astronomer John Wheeler , and the first one was discovered in There are three types: Stellar black holes â€” small but deadly When a star burns through the last of its fuel, it may collapse, or fall into itself. But when a larger star collapses, it continues to compress and creates a stellar black hole. Black holes formed by the collapse of individual stars are relatively small, but incredibly dense. Such an object packs three times or more the mass of the sun into a city-size range. This leads to a crazy amount of gravitational force pulling on objects around it. Black holes consume the dust and gas from the galaxy around them, growing in size. According the Harvard-Smithsonian Center for Astrophysics , "the Milky Way contains a few hundred million" stellar black holes. Supermassive black holes â€” the birth of giants Small black holes populate the universe, but their cousins, supermassive black holes, dominate. Such black holes are thought to lie at the center of pretty much every galaxy, including the Milky Way. Illustration of a young black hole, such as the two distant dust-free quasars spotted recently by the Spitzer Space Telescope. More photos of black holes of the universe Credit: Large gas clouds could also be responsible, collapsing together and rapidly accreting mass. A third option is the collapse of a stellar cluster, a group of stars all falling together. Intermediate black holes â€” stuck in the middle Scientists once thought black holes came in only small and large sizes, but recent research has revealed the possibility for the existence of mid-size, or intermediate , black holes IMBHs. Such bodies could form when stars in a cluster collide in a chain reaction. Several of these forming in the same region could eventually fall together in the center of a galaxy and create a supermassive black hole. In , astronomers found what appeared to be an intermediate-mass black hole in the arm of a spiral galaxy. Because of the relationship between mass and gravity, this means they have an extremely powerful gravitational force. Virtually nothing can escape from them â€” under classical physics, even light is trapped by a black hole. Instead, scientists must rely on the radiation that is emitted as dust and gas are drawn into the dense creatures. Supermassive black holes, lying in the center of a galaxy, may find themselves shrouded by the dust and gas thick around them, which can block the tell-tale emissions. Black holes are strange regions where gravity is strong enough to bend light, warp space and distort time. Bright jets of material traveling at near-relativistic speeds are created. Although the black hole itself remains unseen, these powerful jets can be viewed from great distances. Black holes have three "layers" â€” the outer and inner event horizon and the singularity. The event horizon of a black hole is the boundary around the mouth of the black hole where light loses its ability to escape. Once a particle crosses the event horizon, it cannot leave. Gravity is constant across the event horizon. The inner region of a black hole, where its mass lies, is known as its singularity , the single point in space-time where the mass of the black hole is concentrated. Under the classical mechanics of physics, nothing can escape from a black hole. However, things shift slightly when quantum mechanics are added to the equation. Under quantum mechanics, for every particle, there is an antiparticle, a particle with the same mass and opposite electric charge. When they meet, particle-antiparticle pairs can annihilate one another. If a particle-antiparticle pair is created just beyond the reach of the event horizon of a black hole, it is possible to have one drawn into the black hole itself while the other is ejected. The result is that the event horizon of the black hole has been reduced and black holes can decay, a process that is rejected under classical mechanics. Scientists are still working to understand the equations by which black holes function. Shining light on binary black holes In , astronomers using the Laser Interferometer Gravitational-wave Observatory LIGO made the first detection of gravitational waves. Since then, the instrument has observed several other incidents. The gravitational waves spotted by LIGO came from merging stellar black holes. As a pair of black holes spirals around one another, they can spin in the same direction or they can be completely different. There are two theories on how binary black holes form.

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The first suggests that they formed at about the same time, from two stars that were born together and died explosively at about the same time. The companion stars would have had the same spin orientation, so the black holes they left behind would, as well. Under the second model, black holes in a stellar cluster sink to the center of the cluster and pair up. These companions would have random spin orientations compared to one another. But a study in Nature suggests that quantum effects would cause the event horizon to act much like a wall of fire, instantly burning anyone to death. Black holes do not "suck. Instead, objects fall into them. The first object considered to be a black hole is Cygnus X Rockets carrying Geiger counters discovered eight new X-ray sources. In , scientists detected radio emissions coming from Cygnus X-1, and a massive hidden companion was found and identified as a black hole. Cygnus X-1 was the subject of a friendly wager between Stephen Hawking and a fellow physicist Kip Thorne , with Hawking betting that the source was not a black hole. In , he conceded defeat. Rapidly expanding space may have squeezed some regions into tiny, dense black holes less massive than the sun. If a star passes too close to a black hole, it can be torn apart. Astronomers estimate there are anywhere from 10 million to a billion stellar black holes, with masses roughly three times that of the sun, in the Milky Way. The interesting relationship between string theory and black holes gives rise to more types of massive giants than found under conventional classical mechanics. Black holes remain terrific fodder for science fiction books and movies. Check out the science behind the movie " Interstellar ," which relied heavily on theoretical physicist Kip Thorne to bring real science to the Hollywood feature. In fact, work with the special effects of the blockbuster lead to an improvement in the scientific understanding of how distant stars might appear when seen near a fast-spinning black hole.

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Chapter 4 : Structure of Black Holes

In a new lecture, Stephen Hawking has proposed the idea of using radiation emitted by mini black holes to power the Earth. could escape from their gravitational pull. Then, in , Hawking.

To an observer it would just appear as a sphere of perfect blackness. A Black Hole is an object for which nothing can get a high enough escape velocity to get away from it. Think of a cannonball being fired straight up in the air. As it goes up it will be slowed down by gravity and come crashing back down. If the speed is high enough however it will keep going until it escapes the gravitational pull. When the body is outside of the gravitational pull, its kinetic energy and potential energy will be 0, so if we equate them we get an expression for the escape velocity: The formula contains no mass of the escaping object, if you wanted to get a space shuttle off the earth you would have to get it to the same speed as if you wanted to get a pebble off the earth, the difference being the amount of energy it would take getting something as heavy as a space shuttle up to the right speed. Cambridge scientist John Michell argued that if you made the value of M big enough in the escape velocity formula, then you could get a value for v that was bigger than the speed of light. This is a Black Hole. Forming a Black hole Naturally occurring black holes form when stars collapse. The value of the constant is 6. When the force of gravity from a star becomes bigger than the outwards pressure caused by its temperature then the force starts to make the star collapse, pulling all its mass inwards to a central point. This point gets smaller and smaller and denser and denser as all of the stars mass is squashed into a tiny point. Not all collapsing stars form black holes however. Point of No Return Once an object has been compressed to Schwarzschild radius it will continue to collapse until it becomes a singularity. The Event Horizon is the last distance from which light can escape the pull of the black hole. Inside the event horizon, everything, including light, must move inward, getting crushed at the centre. A diagram showing the arrangement of the singularity, event horizon and the Schwarzchild radius. The event horizon itself is not some physical barrier in space, it just represents the last distance at which it is possible to escape the gravitational pull. Due to the extreme nature of gravity around the event horizon some very weird things can happen. Things moving away from a body get slowed down by the gravitational pull, the bigger the pull the more things get slowed down. Also the closer you are the more you are going to be slowed down. As we sit at a safe distance and watch the unlucky person get closer and closer they seem to slow down! Stuff moving away is meant to slow down; stuff moving towards the black hole should speed up! The way we see the person falling in is through photons particles of light being reflected off them and into our eye. As they get closer to the black hole the photons get slower and slower due to the increase of gravitational force, so they take longer to reach to reach the observer. A diagram to show what occurs when something falls into a black hole The photons given off when the person crosses the even horizon will be slowed down to 0 by the gravity and so an observer will never see them disappear. A Hot Black Hole? Despite the fact that black holes just sit there in space sucking things in with their enormous gravity, it is possible for them to radiate, and thus have a temperature. In the vacuum of space particle and antiparticles are continuously created and annihilated randomly. The particle that is left can then fly off into space as a real particle. A diagram showing particle-antiparticle pairs being separated when forming near a black holw To someone observing from a safe distance, it would appear that the black hole is radiating, and therefore will have a temperature. This temperature was found by Stephen Hawking as 4 where we have the speed of light , Plancks constant.

Chapter 5 : Black Holes | Science Mission Directorate

A black hole is a point in space with so much gravity that not even light (the fastest thing around) can escape, hence the name. To an observer it would just appear as a sphere of perfect blackness.

Here is another chance to read it. It could happen to anyone. Whatever the circumstances, at some point we all find ourselves confronted with the age-old question: You might expect to get crushed, or maybe torn to pieces. But the reality is stranger than that. The instant you entered the black hole, reality would split in two. In one, you would be instantly incinerated, and in the other you would plunge on into the black hole utterly unharmed. View image of Heavy objects warp the fabric of space itself Credit: Einstein taught us that gravity warps space itself, causing it to curve. So given a dense enough object, space-time can become so warped that it twists in on itself, burrowing a hole through the very fabric of reality. A massive star that has run out of fuel can produce the kind of extreme density needed to create such a mangled bit of world. As it buckles under its own weight and collapses inward, space-time caves in with it. The gravitational field becomes so strong that not even light can escape, rendering the region where the star used to be profoundly dark: The event horizon is ablaze with energy. Quantum effects at the edge create streams of hot particles that radiate back out into the universe. This is called Hawking radiation, after the physicist Stephen Hawking, who predicted it. Given enough time, the black hole will radiate away its mass, and vanish. As you go deeper into the black hole, space becomes ever more curvy until, at the centre, it becomes infinitely curved. This is the singularity. Space and time cease to be meaningful ideas, and the laws of physics as we know them â€" all of which require space and time â€" no longer apply. What happens here, no one knows. The back of a bookcase? View image of In a black hole, space becomes infinitely curved Credit: As you accelerate toward the event horizon, Anne sees you stretch and contort, as if she were viewing you through a giant magnifying glass. However, your words reach her ever more slowly, the light waves stretching to increasingly lower and redder frequencies: You remain plastered there, motionless, stretched across the surface of the horizon as a growing heat begins to engulf you. According to Anne, you are slowly obliterated by the stretching of space, the stopping of time and the fires of Hawking radiation. Now, something even stranger happens: View image of The boundary of a black hole might be a blazing firewall Credit: In a big enough black hole, you could live out the rest of your life pretty normally After all, the event horizon is not like a brick wall floating in space. The force of gravity would be much stronger at your feet than at your head, stretching you out like a piece of spaghetti. But lucky for you this is a big one, millions of times more massive than our Sun, so the forces that might spaghettify you are feeble enough to be ignored. In fact, in a big enough black hole, you could live out the rest of your life pretty normally before dying at the singularity. Time only goes forwards, never backwards, and it pulls us along against our will , preventing us from turning around. In a sense, it really is time that pulls you in toward the singularity. At this point you might want to stop and ask yourself a pressing question: What the hell is wrong with Anne? View image of "Hawking radiation" flows out of the event horizon Credit: From her point of view, you really have been burned to a crisp at the horizon. She could even collect your ashes and send them back to your loved ones. You have to be in two places, but there can only be one copy of you On the other hand, the laws of physics also require that you sail through the horizon without encountering hot particles or anything out of the ordinary. So the laws of physics require that you be both outside the black hole in a pile of ashes and inside the black hole alive and well. You have to be in two places, but there can only be one copy of you. Somehow, the laws of physics point us towards a conclusion that seems rather nonsensical. Physicists call this infuriating conundrum the black hole information paradox. Luckily, in the s they found a way to resolve it. Science Photo Library Leonard Susskind realized that there is no paradox, because no one person ever sees your clone. Anne only sees one copy of you. You only see one copy of you. You and Anne can never compare notes. So, no laws of physics are broken. Reality depends on whom you ask Unless, that is, you demand to know which story is really true. Are you really dead or are you really alive? The great secret that black holes have revealed to us is that there is no really. Reality depends on whom you ask. In the summer of , the physicists Ahmed Almheiri, Donald Marolf, Joe Polchinski and James Sully, collectively known as

AMPS, devised a thought experiment that threatened to upend everything we thought we knew about black holes. View image of Nobody is sure what lies inside a black hole Credit: Anne might sneak a peek behind the horizon But what if there was a way for her to find out what was on the other side of the horizon, without actually crossing it? Anne might sneak a peek behind the horizon, using a little trick that Einstein called "spooky action-at-a-distance". This happens when two sets of particles that are separated in space are mysteriously "entangled". The AMPS idea went something like this. Each bit of information can only be entangled once If her story is right, and you are a goner, scrambled amongst the Hawking radiation outside the black hole, then A must be entangled with another bit of information, B, which is also part of the hot cloud of radiation. That means A can only be entangled with B or with C, not with both. So Anne takes her bit, A, and puts it through her handy entanglement-decoding machine, which spits out an answer: Do you glide right through and live a normal life? If the answer turns out to be C, then your story wins, but the laws of quantum mechanics are broken. If A is entangled with C, which is deep inside the black hole, then that piece of information is lost to Anne forever. That breaks the quantum law that information can never be lost. Instead of sailing straight through the horizon, as relativity says you should, you hit a burning firewall. It would take Anne an extraordinarily long time to decode the entanglement Physicists have spent more than a century trying to reconcile general relativity with quantum mechanics , knowing that eventually one or the other was going to have to give. The solution to the firewall paradox should tell us which, and point the way to an even deeper theory of the universe. Figuring out which other bit of information A is entangled with is an extraordinarily complicated problem. In they calculated that, even given the fastest computer that the laws of physics would allow, it would take Anne an extraordinarily long time to decode the entanglement. By the time she had an answer, the black hole would have long evaporated , disappearing from the universe and taking with it the threat of a deadly firewall. View image of Centaurus A has a black hole Credit: That would leave both stories simultaneously true, reality intriguingly observer-dependent, all the laws of physics intact, and no one in danger of running into an inexplicable wall of fire. If the true nature of reality lies hidden somewhere, the best place to look is a black hole It also gives physicists something new to think about: This may open the door to something deeper still. If the true nature of reality lies hidden somewhere, the best place to look is a black hole. Or send Anne in.

Chapter 6 : A black hole is not a hole - Wake County Public Libraries

Supermassive black holes are likely the power source for Active Galactic Nuclei (AGN), the bulging glow seen in many galactic cores. AGNs might be the result of a huge black hole gobbling up whole stars and pulling dust and gas from the nearby interstellar medium with such fury that the energy produced in this relatively small region (the size.

Share Black Holes A star exists in a delicate balance between the crushing force of gravity, on the one hand, and the push of incredibly hot gases on the other. This balance exists as long as there is fuel for the fusion process that powers the star. What happens when the star runs out of fuel? Then, gravity collapses the star. The more massive the star, the more drastic the collapse and the more condensed the remaining object. Cas A is the remnant of a star that exploded about years ago. The X-ray image shows an expanding shell of hot gas produced by the explosion. The collapse produces enough pressure to squeeze atoms right out of existence, leaving electrons and nuclei packed tightly together in an object about the size of Earth. The result is called a white dwarf. A star six to eight times larger than the sun: Upon exhausting its nuclear fuel, a star this large undergoes a catastrophic explosion as a supernova. See Neutrino Astrophysics The force of gravity in the leftover object is so strong that the electrons are jammed into the nuclei to make a neutron star, with a diameter of only about 16 km. A star ten or more times larger than the sun: At this size, the force of gravity collapses the neutron core right out of existence to form a black hole. Gravity near the black hole is so strong that nothing can escape, not even light. More precisely, any matter or radiation inside a sphere called the event horizon falls inward and cannot escape. For a black hole with ten times the mass of the sun, the radius of the event horizon is about 30 km. History of Black Holes The existence of black holes was predicted well before the 20th century. About a hundred years after Newton worked out his theory of gravitation, the English astronomer John Michell recognized in the possibility that the gravity of a very large star might be so great that nothing, not even light, could escape it. In the s, other physicists, including Robert Oppenheimer, who later became the director of the Manhattan Project, produced more detailed calculations. There are two classes of black holes: Our own Galaxy harbors thousands of stellar black holes, and new observations show that most galaxies, including possibly our own, have a supermassive black hole at their core. Within both classes of black holes, space and time as we know it collapse. Thus, black holes are cosmic laboratories, allowing us to explore the ultimate limits of our physical laws and of gravity. Disk around a black hole in Galaxy NGC A black hole is defined by a surface called the event horizon, the point at which gravity is so strong that nothing, not even light, can escape. The stellar matter itself is crushed into a singularity at the center, hidden behind the event horizon. The event horizon of a galactic black hole is only a few miles across. In supermassive black holes, it is only about the size of our Solar System. Supermassive black holes are likely the power source for Active Galactic Nuclei AGN , the bulging glow seen in many galactic cores. AGNs might be the result of a huge black hole gobbling up whole stars and pulling dust and gas from the nearby interstellar medium with such fury that the energy produced in this relatively small region the size of our Solar System outshines the entire galaxy. How do we go about observing black holes if they are so compact and emit no visible light? There are a couple of tricks. Stellar black holes are often part of a binary star system, two stars revolving around each other. What we see from Earth is a visible star orbiting around what appears to be nothing. In reality, it is orbiting around the black hole. We can infer the mass of the black hole by the way the visible star is orbiting around it. The larger the black hole, the greater the gravitational pull, and the greater the effect on the visible star. Because a black hole has such a powerful gravitational force, a galactic black hole in a binary system can literally tear apart its companion star. Gas from the companion swirls into the black hole like water down a drain. The swirling gas is what we call an accretion disk. As the gas gets closer to the black hole, it heats up from the friction of ever faster moving gas molecules. Gas heated to these temperatures releases tremendous amounts of energy in the form of X-rays. Supermassive black holes also have an accretion disk that emits X-rays. This is formed not by a single star, as in a binary system, but by the great amounts of gas present in the regions between stars. In about 10 percent of supermassive black holes, jets of energized matter thousands of light-years in length shoot out in opposite directions. This can be detected in radio, visible, X-ray and gamma-ray wavelengths. These jets accelerate matter to nearly the speed of light through a mechanism not well understood. From small to large-scale black holes, many questions abound: How is material fed directly into the black hole? How do jets form? Why do some black holes have jets, while many more do not? What keeps the jets powered for millions of years? Why are AGNs more common in the past than today? How do supermassive black holes participate in the formation and evolution of galaxies? What are the masses and spins of black holes? Exploring the Universe Text courtesy of NASA Different types of telescopes detect different types, or wavelengths, of light--from microwaves to visible light what our eyes can detect to high energy X-ray photons and gamma rays. Each wavelength band is important for composing a full view of the Universe. Optical telescopes, such as Hubble Space Telescope, generate brilliant images of stars and galaxies, both near and far. Hubble also measures the sizes, distances and compositions of celestial objects. Radio telescopes, however, were the first to detect quasars, extremely distant galaxies that emit incredible amounts of radio energy. Radio telescopes also provided the first evidence of planets outside our Solar System. High energy gamma-ray telescopes have discovered the most energetic explosion since the Big Bang. Thus, the entire electromagnetic spectrum is important for a complete picture, because different objects emit the bulk of their radiation at different wavelengths. Color composite of the supernova remnant E X-ray blue , optical green , and radio red. Courtesy of NASA An X-ray telescope collects photons created naturally in some of the most violent and energetic events in the Universe: Rather, it collects these tiny packets of high energy that form at extremely high temperatures. The Sun produces some X-rays, particularly during a solar flare. However, X-ray telescopes focus far beyond our Solar System and can study black holes, stellar explosions, galaxies that release great amounts of X-rays from their centers, and the pervasive, but optically invisible, hot gas that dominates space between stars and galaxies. Yet, in designing Constellation-X, scientists wanted an X-ray telescope similar to the large Earth-bound telescopes to collect as much X-ray light as possible. The four satellites are light enough to be launched individually or in pairs, yet combine to provide a sensitivity times greater than any past or current X- ray satellite mission. Essentially, scientists will be able to collect more data in an hour than they would have collected in days or weeks with current X-ray telescopes. We will learn about thousands of faint X- ray emitting sources, not just the bright sources available to us today. It is less expensive to build and launch smaller, identical telescopes. And with separate launches for individual telescopes - or perhaps for pairs of telescopes, if the design permits - we avoid putting all our eggs in one rocket, so to speak. Constellation-X is modeled after the Keck Observatory, twin optical telescopes each 10 meters 33 feet wide, positioned high atop Mauna Kea in Hawaii. Both observatories have superior collecting areas, or apertures, for analyzing the components of light. Both Keck and Constellation-X are the complements to the great high-angular-resolution space telescopes: No single telescope can do it all. Hubble, along with its many excellent features, provides fantastic images of distant galaxies with unprecedented clarity. The Earth-based Keck supports Hubble, however, by collecting enough light waves to study the gas in those distant galaxies. Likewise, the Chandra Observatory, to be launched by the year , will have the best imaging resolution of any X-ray telescope so far. Scientists will then use the unparalleled data from Constellation-X together with Chandra in analyzing X-ray light and forming a more complete picture of the X-ray Universe. Constellation-X will document these objects and regions with images, and, more importantly, with spectra. Spectra, the soul of Constellation-X, are like the fingerprints of elements in far-away stars and dusty clouds of hot gas. These diagrams of spectral energy patterns can reveal almost every characteristic of a distant gas, solely from the light it emits. With high- resolution X-ray spectroscopy, we can zoom in to within a few kilometers of the border of a black hole, as close to the black hole itself as any observations can theoretically get. Spectra can be used to see how extreme gravity around a black hole affects the composition, pressure, density, temperature and velocity of the gas swirling into it. Spectra of black holes, supernova remnants and galaxy clusters provided by Constellation-X will be the next best thing to reaching out and touching these objects with our hands. Data from current telescopes can take us near a black hole, but Constellation-X will take us to within a few miles of its edge. It will be able to measure the mass and spin of a black hole, two of its defining characteristics. Such measurements will enable scientists to begin to answer the many questions that remain about the formation and evolution of black holes, and about how the laws of physics behave in extreme environments.

Chapter 7 : Gravity-powered Energy | HowStuffWorks

As your feet begin to get stretched by gravity's pull, they will become increasingly more attracted as they inch closer to the centre of the black hole. The closer they get, the faster they move. But the top half of your body is farther away and so is not moving toward the centre as fast.

This is the "point of no return". Any object, even light, that is within this radius cannot escape the gravitational pull of the black hole The Schwarzschild Radius: This is a disk composed of stellar material that is spiraling towards that black hole The Ergosphere: If the black hole is rotating, then as it spins, its mass causes the space time around the black hole to rotate as well. This region is called the ergosphere. Located at the very center of the black hole is the singularity. This is the location of extremely large mass and almost zero volume, creating a point of infinite density [7]. Outside the singularity is the event horizon. This is the radius at which if matter or light gets any closer, it cannot escape the gravitational pull of the black hole. The event horizon is defined as the point at which the escape velocity of a particle would have to equal the speed of light [7]. Another name for the radius of the event horizon is the Schwarzschild radius. This is the radius away from the black hole such that the escape velocity equals the speed of light [2]. To find the Schwarzschild radius one simple uses the speed of light as the escape velocity [2]. By setting vescape equal to the speed of light c, then: This is formed by stellar materials that are close to the black hole and are spinning toward the center, continuously pulled by the force of gravity [8]. As these particles spiral towards the singularity they collide and heat up, emitting x-rays [8]. If the black hole is rotating, then an area called the ergosphere also exists. The mass of the black hole is so great and the force of gravity so strong that the space time around the rotating black hole is dragged along and moved, a phenomenon called frame dragging [9]. The current best explanation for this is the theory that there are powerful magnetic fields being emitted from the black hole [8]. So, these jets of gas are the result of charged particles orbiting these magnetic fields being emitted from the black hole [8].

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Chapter 8 : gravity - Pulling of Light by a Black Hole? - Physics Stack Exchange

Black holes warp space and time to such an extreme that inside the black hole's horizon, space and time actually swap roles. In a sense, it really is time that pulls you in toward the singularity.

Rather, it is a great amount of matter packed into a very small area - think of a star ten times more massive than the Sun squeezed into a sphere approximately the diameter of New York City. The result is a gravitational field so strong that nothing, not even light, can escape. In recent years, NASA instruments have painted a new picture of these strange objects that are, to many, the most fascinating objects in space. Intense X-ray flares thought to be caused by a black hole devouring a star. Video Watch the Video The idea of an object in space so massive and dense that light could not escape it has been around for centuries. A video about black holes. We can, however, infer the presence of black holes and study them by detecting their effect on other matter nearby. If a black hole passes through a cloud of interstellar matter, for example, it will draw matter inward in a process known as accretion. A similar process can occur if a normal star passes close to a black hole. In this case, the black hole can tear the star apart as it pulls it toward itself. As the attracted matter accelerates and heats up, it emits x-rays that radiate into space. Recent discoveries offer some tantalizing evidence that black holes have a dramatic influence on the neighborhoods around them - emitting powerful gamma ray bursts, devouring nearby stars, and spurring the growth of new stars in some areas while stalling it in others. Smaller stars become dense neutron stars, which are not massive enough to trap light. If the total mass of the star is large enough about three times the mass of the Sun , it can be proven theoretically that no force can keep the star from collapsing under the influence of gravity. However, as the star collapses, a strange thing occurs. As the surface of the star nears an imaginary surface called the "event horizon," time on the star slows relative to the time kept by observers far away. When the surface reaches the event horizon, time stands still, and the star can collapse no more - it is a frozen collapsing object. Astronomers have identified a candidate for the smallest-known black hole. Video Watch the Video Even bigger black holes can result from stellar collisions. Babies and Giants Although the basic formation process is understood, one perennial mystery in the science of black holes is that they appear to exist on two radically different size scales. On the one end, there are the countless black holes that are the remnants of massive stars. Peppered throughout the Universe, these "stellar mass" black holes are generally 10 to 24 times as massive as the Sun. Most stellar black holes, however, lead isolated lives and are impossible to detect. Judging from the number of stars large enough to produce such black holes, however, scientists estimate that there are as many as ten million to a billion such black holes in the Milky Way alone. On the other end of the size spectrum are the giants known as "supermassive" black holes, which are millions, if not billions, of times as massive as the Sun. Astronomers believe that supermassive black holes lie at the center of virtually all large galaxies, even our own Milky Way. Astronomers can detect them by watching for their effects on nearby stars and gas. This chart shows the relative masses of super-dense cosmic objects. Read the full article Historically, astronomers have long believed that no mid-sized black holes exist. One possible mechanism for the formation of supermassive black holes involves a chain reaction of collisions of stars in compact star clusters that results in the buildup of extremely massive stars, which then collapse to form intermediate-mass black holes. The star clusters then sink to the center of the galaxy, where the intermediate-mass black holes merge to form a supermassive black hole.

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Chapter 9 : HubbleSite: Black Holes: Gravity's Relentless Pull

Supermassive black holes blast winds outward in a spherical shape, as depicted here in this artist's conception of a black hole. Credit: NASA/JPL-Caltech There's something inherently fascinating.

Share via Email Thanks to German astronomers, we now have the most accurate measurements yet of the giant black hole that sits at the centre of our galaxy. And what a beast it is: Lucky, then, that it is 27, light years away. Researchers from the Max Planck Institute for Extraterrestrial Physics used two telescopes operated by the European Southern Observatory in Chile to watch stars as they circled the centre of the Milky Way. The year study, now published in the Astrophysical Journal , has proved beyond doubt that lurking at the very centre of the galaxy is a black hole. Black holes are clearly intriguing , and not just to scientists. Earlier today, a colleague known more for his in-depth investigations into the wrongdoings of governments and multinationals than his knowledge of quantum gravity, asked what seems like a simple question: To begin with, he pointed out that scientists should only ask questions that can be answered, and since it is impossible to get information out of a black hole in the form of light, for example we can never really know. Black holes are created when large stars explode and collapse in on themselves. Many will have masses similar to our own sun, but others grow to much larger masses. Theoretical physicists have thought long and hard about what goes on inside black holes and their conclusions are mind-bending to say the least. Despite the fact that they suck in material from anything and everything that strays too close, they are empty. The mass of a black hole is confined to an infinitely small point at its centre, called a singularity. How much blackness surrounds a singularity â€” in effect, the size of the black hole â€” is defined by the strength of its gravitational pull. Far away from a black hole, light can zip around as usual, lighting up the heavens as it goes. But closer to a black hole, gravity becomes stronger and stronger until eventually, not even light can move fast enough to escape its pull. This is why a singularity is surrounded by a vast sphere of darkness. The easiest thing for astronomers would be light, but a black hole is so massive not even light can escape so no information can get out," he said. A Life in Physics". He said black holes teach us that "space can be crumpled like a piece of paper into an infinitesimal dot, that time can be extinguished like a blown out flame, and that the laws of physics that we regard as sacred, as immutable, are anything but.