TIME TRAVELS LIGHT pdf

1: Is Time Travel Possible?| Explore | www.enganchecubano.com

Using a weird phenomenon in which particles of light seem to travel at faster-than-light speeds, scientists have shown that waves of light can seem to travel backward in time.

April 19, The new experiment also shows other bizarre effects of light, such as pairs of images forming and annihilating each other. Taken together, the results finally prove a century-old prediction made by British scientist and polymath Lord Rayleigh. The phenomenon, called time reversal, could allow researchers to develop ultra-high-speed cameras that can peer around corners and see through walls. Rayleigh reasoned that, because the speed of sound is fixed, an object traveling faster than that while spewing out sound would result in sound waves that would seem to travel in the opposite direction of the object and thus seem to be reversed in time orientation. For instance, a phonograph on a plane traveling at Mach 2, or twice the speed of sound , would seem to play the music backward. No scientists really doubted this notion, but there was no easy way to test it. Sound travels at The scattering and absorption of the sound waves in the air would make the music completely inaudible by that time, Faccio said. Light travels much, much faster than sound, at million mph 1. And the wavelengths themselves are tiny, meaning the time reversal can be demonstrated in a normal-size room. The researchers were also interested in studying this idea because they were developing ultra-high-speed cameras that could peer around corners , and the phenomenon could affect their algorithms. Nothing can travel faster than the speed of light. To create a faster-than-light source, the team used a strange phenomenon called illumination fronts , which had previously been described in a series of fascinating thought experiments. The trick behind illumination fronts is that, while an image may be traveling faster than light, the photons themselves never exceed light speed. Imagine taking a laser pointer and flicking the point across a vast and distant wall. While the photons traveling from the laser pointer to the wall are moving at their ordinary speed, because the light hits the wall at an angle, the dot on the wall the illumination front always moves faster than that. The Plausibility of 10 Sci-Fi Concepts] Freezing photons in midair Next, however, the team had to find some way to capture the speedy paths of images as they zoomed across a wall. How to Freeze Light] To catch time reversal in the act, the team created an illumination front by projecting a single line of light on a screen and moving that line across the screen faster than the speed of light. At the same time, they captured the reflected light in motion using a super-high-speed camera. The camera snapped photos in a few picoseconds, or trillionths of a second, during which time photons travel just a few feet. Sure enough, the camera captured the line on the wall moving in the opposite direction from the way they moved the line, as if it had traveled backward in time. Self-annihilating twins In a second experiment, the team verified an even more bizarre effect, called pair creation and annihilation. Robert Nemiroff, a physicist at Michigan Technological University, predicted this effect for astronomical objects in a study posted online in May in the preprint journal arXiv. Faccio and his colleagues had an illumination front travel across a curved screen. As the speed of the projected lines exceeded light speed, a pair of lines was created, and the two lines moved away from each other. Using a different curvature, the pair of lines moved toward each other, merged and then annihilated each other, the researchers reported Friday April 15 in the journal Science Advances. This kind of "supersight" requires scientists to analyze the paths that light particles take as they bounce and scatter off various objects. Normally, light travels so fast that, to the human eye, the light coming from many different locations seems to appear instantaneously, making it impossible for the eye to resolve these different light paths and "see" behind corners. But because high-speed cameras can capture the light in motion, researchers can reconstruct the shape of objects that might not be in the immediate line of sight. However, the mathematical calculation of these paths would need to account for the possibility that some of the light rays they see are time-reversed, because they are coming from an illumination front, Faccio said. The new findings apply to any type of wave, Faccio said. The new paper also has some other interesting implications, said Nemiroff, who was not involved in the current study.

2: Time and the Speed of Light

Slow time travel: In "Primer" (), a traveler stays in a box while time traveling. For each minute they want to go back in time, they need to stay in the box for a minute.

In this theory, light is described by the fundamental excitations or quanta of the electromagnetic field, called photons. In QED, photons are massless particles and thus, according to special relativity, they travel at the speed of light in vacuum. Extensions of QED in which the photon has a mass have been considered. The limit obtained depends on the model used: Another reason for the speed of light to vary with its frequency would be the failure of special relativity to apply to arbitrarily small scales, as predicted by some proposed theories of quantum gravity. Refractive index In a medium, light usually does not propagate at a speed equal to c; further, different types of light wave will travel at different speeds. An actual physical signal with a finite extent a pulse of light travels at a different speed. The blue dot moves at the speed of the ripples, the phase velocity; the green dot moves with the speed of the envelope, the group velocity; and the red dot moves with the speed of the foremost part of the pulse, the front velocity The phase velocity is important in determining how a light wave travels through a material or from one material to another. It is often represented in terms of a refractive index. The refractive index of air is approximately 1. In exotic materials like Boseâ€"Einstein condensates near absolute zero, the effective speed of light may be only a few metres per second. However, this represents absorption and re-radiation delay between atoms, as do all slower-than-c speeds in material substances. As an extreme example of light "slowing" in matter, two independent teams of physicists claimed to bring light to a "complete standstill" by passing it through a Boseâ€"Einstein condensate of the element rubidium , one team at Harvard University and the Rowland Institute for Science in Cambridge, Mass. However, the popular description of light being "stopped" in these experiments refers only to light being stored in the excited states of atoms, then re-emitted at an arbitrarily later time, as stimulated by a second laser pulse. During the time it had "stopped," it had ceased to be light. This type of behaviour is generally microscopically true of all transparent media which "slow" the speed of light. In other materials, it is possible for the refractive index to become smaller than 1 for some frequencies; in some exotic materials it is even possible for the index of refraction to become negative. A pulse with different group and phase velocities which occurs if the phase velocity is not the same for all the frequencies of the pulse smears out over time, a process known as dispersion. Certain materials have an exceptionally low or even zero group velocity for light waves, a phenomenon called slow light , which has been confirmed in various experiments. It is impossible to transmit information with a light pulse any faster than the speed of the earliest part of the pulse the front velocity. It can be shown that this is under certain assumptions always equal to c. When a charged particle does that in a dielectric material, the electromagnetic equivalent of a shock wave , known as Cherenkov radiation , is emitted. This applies from small to astronomical scales. On the other hand, some techniques depend on the finite speed of light, for example in distance measurements. Small scales In supercomputers , the speed of light imposes a limit on how quickly data can be sent between processors. Processors must therefore be placed close to each other to minimize communication latencies; this can cause difficulty with cooling. If clock frequencies continue to increase, the speed of light will eventually become a limiting factor for the internal design of single chips. The relative sizes and separation of the Earthâ€"Moon system are shown to scale. Similarly, communications between the Earth and spacecraft are not instantaneous. There is a brief delay from the source to the receiver, which becomes more noticeable as distances increase. This delay was significant for communications between ground control and Apollo 8 when it became the first manned spacecraft to orbit the Moon: As a consequence of this, if a robot on the surface of Mars were to encounter a problem, its human controllers would not be aware of it until at least five minutes later, and possibly up to twenty minutes later; it would then take a further five to twenty minutes for instructions to travel from Earth to Mars. NASA must wait several hours for information from a probe orbiting Jupiter, and if it needs to correct a navigation error, the fix will not arrive at the spacecraft for an equal amount of time, creating a risk of the correction not arriving in time. Receiving light and other signals from distant astronomical sources can even take much longer. Astronomical distances are sometimes expressed in light-years , especially in popular science publications and media. Proxima Centauri , the closest star to Earth after the Sun, is around 4. Distance measurement Radar systems measure the distance to a target by the time it takes a radio-wave pulse to return to the radar antenna after being reflected by the target: The Lunar Laser Ranging Experiment , radar astronomy and the Deep Space Network determine distances to the Moon, [83] planets [84] and spacecraft, [85] respectively, by measuring round-trip transit times. High-frequency trading The speed of light has become important in high-frequency trading , where traders seek to gain minute advantages by delivering their trades to exchanges fractions of a second ahead of other traders. One way is to measure the actual speed at which light waves propagate, which can be done in various astronomical and earth-based setups. Historically, the most accurate results have been obtained by separately determining the frequency and wavelength of a light beam, with their product equalling c. Consequently, accurate measurements of the speed of light yield an accurate realization of the metre rather than an accurate value of c. Astronomical measurements Measurement of the speed of light using the eclipse of Io by Jupiter Outer space is a convenient setting for measuring the speed of light because of its large scale and nearly perfect vacuum. Historically, such measurements could be made fairly accurately, compared to how accurately the length of the reference distance is known in Earth-based units. It is customary to express the results in astronomical units AU per day. Another method is to use the aberration of light , discovered and explained by James Bradley in the 18th century. A moving observer thus sees the light coming from a slightly different direction and consequently sees the source at a position shifted from its original position. From the angular difference in the position of stars maximally By combining many such measurements, a best fit value for the light time per unit distance could be obtained. The relative uncertainty in these measurements is 0. On the way from the source to the mirror, the beam passes through a rotating cogwheel. At a certain rate of rotation, the beam passes through one gap on the way out and another on the way back, but at slightly higher or lower rates, the beam strikes a tooth and does not pass through the wheel. Knowing the distance between the wheel and the mirror, the number of teeth on the wheel, and the rate of rotation, the speed of light can be calculated. Because the mirror keeps rotating while the light travels to the distant mirror and back, the light is reflected from the rotating mirror at a different angle on its way out than it is on its way back. From this difference in angle, the known speed of rotation and the distance to the distant mirror the speed of light may be calculated.

3: Time travel - Wikipedia

One way to achieve time travel into the future would be travelling at the speed of light in space, as first theorised by Albert Einstein. Indeed Cosmonaut Sergei Krikalev technically lives in the.

November 14, Franchises ranging from "Doctor Who" to "Star Trek" to "Back to the Future" have seen humans get in a vehicle of some sort and arrive in the past or future, ready to take on new adventures. The reality, however, is more muddled. Not all scientists believe that time travel is possible. Some even say that an attempt would be fatal to any human who chooses to undertake it. Understanding time What is time? While most people think of time as a constant, physicist Albert Einstein showed that time is an illusion; it is relative â€" it can vary for different observers depending on your speed through space. To Einstein, time is the "fourth dimension. Time provides another coordinate â€" direction â€" although conventionally, it only moves forward. Conversely, a new theory asserts that time is "real. Approaching the speed of light, a person inside a spaceship would age much slower than his twin at home. Picture a four-dimensional fabric called space-time. When anything that has mass sits on that piece of fabric, it causes a dimple or a bending of space-time. The bending of space-time causes objects to move on a curved path and that curvature of space is what we know as gravity. Both the general and special relativity theories have been proven with GPS satellite technology that has very accurate timepieces on board. Engineers make calibrations to account for the difference. In a sense, this effect, called time dilation, means astronauts are time travelers, as they return to Earth very, very slightly younger than their identical twins that remain on the planet. Through the wormhole General relativity also provides scenarios that could allow travelers to go back in time, according to NASA. The equations, however, might be difficult to physically achieve. One possibility could be to go faster than light, which travels at , miles per second , kilometers per second in a vacuum. This appears to be physically impossible, although some scientists have extended his equations and said it might be done. A linked possibility, NASA stated, would be to create "wormholes" between points in space-time. Also, the technology needed to create a wormhole is far beyond anything we have today. After spinning this up a few billion revolutions per minute, a spaceship nearby â€" following a very precise spiral around this cylinder â€" could get itself on a "closed, time-like curve", according to the Anderson Institute. There are limitations with this method, however, including the fact that the cylinder needs to be infinitely long for this to work. The black-hole in NGC weighs ,, times more than our own Sun. The ship and its crew would be traveling through time," physicist Stephen Hawking wrote in the Daily Mail in Ten years would pass elsewhere. When they got home, everyone on Earth would have aged five years more than they had. Cosmic strings Another theory for potential time travelers involves something called cosmic strings â€" narrow tubes of energy stretched across the entire length of the ever-expanding universe. These thin regions, left over from the early cosmos, are predicted to contain huge amounts of mass and therefore could warp the space-time around them. The approach of two such strings parallel to each other would bend space-time so vigorously and in such a particular configuration that might make time travel possible, in theory. Time machines It is generally understood that traveling forward or back in time would require a device â€" a time machine â€" to take you there. Time machine research often involves bending space-time so far that time lines turn back on themselves to form a loop, technically known as a "closed time-like curve. BBCAmerica To accomplish this, time machines often are thought to need an exotic form of matter with so-called "negative energy density. Such matter could theoretically exist, but if it did, it might be present only in quantities too small for the construction of a time machine. However, time-travel research suggests time machines are possible without exotic matter. The work begins with a doughnut-shaped hole enveloped within a sphere of normal matter. Inside this doughnut-shaped vacuum, space-time could get bent upon itself using focused gravitational fields to form a closed time-like curve. To go back in time, a traveler would race around inside the doughnut, going further back into the past with each lap. This theory has a number of obstacles, however. The gravitational fields required to make such a closed time-like curve would have to be very strong, and manipulating them would have to be very precise. A classic example is the grandfather paradox, in which a time traveler goes back and kills his parents or his grandfather â€” the major plot line in the "Terminator" movies â€" or otherwise interferes in their relationship â€" think "Back to the Future" â€" so that he is never born or his life is forever altered. If that were to happen, some physicists say, you would be not be born in one parallel universe but still born in another. Others say that the photons that make up light prefer self-consistency in timelines , which would interfere with your evil, suicidal plan. Some scientists disagree with the options mentioned above and say time travel is impossible no matter what your method. The faster-than-light one in particular drew derision from American Museum of Natural History astrophysicist Charles Lu. Also, humans may not be able to withstand time travel at all. Traveling nearly the speed of light would only take a centrifuge, but that would be lethal , said Jeff Tollaksen, a professor of physics at Chapman University, in Using gravity would also be deadly. To experience time dilation, one could stand on a neutron star , but the forces a person would experience would rip you apart first. Time travel in fiction Two articles by Space. Some methods used in fiction include: One-way travel to the future: The traveler leaves home, but the people he or she left behind might age or be dead by the time the traveler returns. In "Interstellar" , there are "tesseracts" available in which astronauts can travel because the vessel represents time as a dimension of space. The book, however, uses supernatural beings to make the travel possible. Travelling the space-time vortex: Time travelling while standing still: In "Primer" , a traveler stays in a box while time traveling. For each minute they want to go back in time, they need to stay in the box for a minute. If they want to go back a day in time, they have to stay there for 24 hours. Traveling faster than light: The Movie" , Superman flies faster than light to go back in time and rescue Lois Lane before she is killed. The concept was also used in the novel "Timescape" by Gregory Benford, in which the protagonist sends hypothetical faster-than-light tachyon particles back to Earth in to warn of disaster. In several "Star Trek" episodes and movies, the Enterprise travels through time by going faster than light. In the comic book and TV series "The Flash," the super-speedster uses a cosmic treadmill to travel through time. Difficult methods to categorize: So is time travel possible? While time travel does not appear possible â€" at least, possible in the sense that the humans would survive it â€" with the physics that we use today, the field is constantly changing. Advances in quantum theories could perhaps provide some understanding of how to overcome time travel paradoxes. One possibility, although it would not necessarily lead to time travel, is solving the mystery of how certain particles can communicate instantaneously with each other faster than the speed of light. In the meantime, however, interested time travelers can at least experience it vicariously through movies, television and books.

4: How Fast Does Light Travel? | The Speed of Light

Continuum erupts with the playful art of percussion. Featured artists TorQ Percussion Quartet and Newfoundland's Rob Power join Artistic Director Ryan Scott with an extended ensemble of lower string instruments.

Ever since Albert Einstein formulated his theory of relativity nearly a century ago, it has been a central tenet of physics that nothing can travel faster than light. Now it is claimed that in certain circumstances, light itself can be accelerated up to times its usual speed. As always, the devil is in the detail. Moving through a vacuum, light travels at , km per second. According to the theory of relativity, it is the ultimate speed limit for the propagation of any physical influence. That includes spacecraft, subatomic particles, radio signals, or anything that might convey information or cause an effect. When light passes through a medium such as air, it is slowed. The effect is best explained by analogy with water waves. Try throwing a stone in a pond to make ripples. Focus on a particular wave crest, and it will appear to move fairly fast, but then take a wider perspective to view the group of waves as a whole, and it travels outwards from the point of disturbance noticeably more slowly. It is almost as if the waves are rushing to get nowhere fast. You can watch as new ripples rise up at the back of the wave group, whiz forwards, and fade away at the front. The same thing happens to light in a medium. It comes about because atoms in the medium create outgoing ripples of light as the primary light wave sweeps by them. When these ripples overlap and combine with the primary wave, they obliterate the parts racing on ahead, suppressing the fast-moving wave front and serving to slow down the group. So light passing through a medium has two associated velocities: A normal medium always reduces the group velocity of light to below its phase velocity, leading to the familiar phenomenon of refraction - the effect that causes a stick to look bent when it is stuck in water. The special feature of the Princeton experiment was the creation of a peculiar state of matter in which this situation is reversed: To achieve this odd state of affairs, the scientists used a gas of cold caesium, and then excited the caesium atoms with a laser. So energised, the atoms do more than cause secondary ripples of light, they amplify the light too. It is this amplification that is the key to boosting the speed of the wave group, reportedly to times the speed of light in a vacuum. Bizarrely, the wave distortion achieved is so large, it causes the group velocity to become negative, which means the peak of the wave pulse appears to exit the gas before it enters. In other words, the light waves seem to run backwards. What makes this result so sensational is the relationship between light speed and causality. The theory of relativity predicts that speed slows time. For example, time passes a bit slower in an aircraft than on the ground, an effect that has been verified using atomic clocks. The time warp is small for everyday motion, but grows without limit as the speed of light is approached. Cosmic rays, for example, travel exceedingly close to the speed of light, and their internal clocks are slowed millions of times. Relativity theory predicts that if a particle could exceed the speed of light, the time warp would become negative, and the particle could then travel backwards in time. As Dr Who fans are aware, travel into the past opens up a nest of paradoxes. For example, suppose a faster-than-light particle is used as a signal to explode a bomb in the very lab that the particle itself is created. If the bomb explodes yesterday, the particle cannot be made today. Either way, you get contradictory nonsense. At stake, then, is the very rationality and causal order of the universe. Allow faster-than-light travel, and the physical world turns into a madhouse. Timing the speed of a pulse of light is fraught with complications, not least because the shape of the pulse changes when it passes through a medium. To make a pulse of a short duration, it is necessary to mix together waves of many different frequencies, and in a medium each wave will propagate differently. As for transmitting information, opinions differ about how to associate it with a pulse that has a complicated, changing shape. The inherent fuzziness in a light pulse made up of many different waves superimposed precludes a clean definition of how fast actual information travels. The problem is closely related to the quantum nature of light, where each frequency component can be thought of as made up of pho tons that behave in some ways like particles. The Princeton physicists believe this fundamental fuzziness associated with a finite pulse of waves prevents information from exceeding the speed of light, so in an operational sense the light barrier remains unbroken and the causal order of the cosmos is still safe. It is intriguing to see how the wave nature of light rescues the theory of relativity from paradox. He will lecture on time travel at the Royal Society on September

5: Time Travel: Theories, Paradoxes & Possibilities

Time travel is the concept of movement between certain points in time, analogous to movement between different points in space by an object or a person, typically using a hypothetical device known as a time machine.

March 6, But some scientists are exploring the possibility that this cosmic speed limit changes. Iscatel Shutterstock The speed of light in a vacuum is , miles per second , kilometers per second , and in theory nothing can travel faster than light. In miles per hour, light speed is, well, a lot: If you could travel at the speed of light, you could go around the Earth 7. Over time, however, measurements of the motion of these wave-like particles became more and more precise. Thanks to the work of Albert Einstein and others, we now understand light speed to be a theoretical limit: History of the theory The first known discourse on the speed of light comes from the ancient Greek philosopher Aristotle, who penned his disagreement with another Greek scientist, Empedocles. Empedocles argued that because light moved, it must take time to travel. Aristotle, believing light to travel instantaneously, disagreed. In , the Italian astronomer Galileo Galilei stood two people on hills less than a mile apart, each holding a shielded lantern. One uncovered his lantern; when the second saw the flash, he uncovered his, as well. By observing how long it took for the light to be seen by the first lantern-holder and factoring out reaction times , he thought he could calculate the speed of light. He determined that light took time to travel from Io to Earth. The eclipses lagged the most when Jupiter and Earth were farthest apart, and were on schedule as they were closer. Two attempts in the mids brought the problem back to Earth. French physicist Hippolyte Fizeau set a beam of light on a rapidly rotating toothed wheel, with a mirror set up 5 miles away to reflect it back to its source. Varying the speed of the wheel allowed Fizeau to calculate how long it took for the light to travel out of the hole, to the adjacent mirror, and back through the gap. Another French physicist, Leon Foucault, used a rotating mirror rather than a wheel. The two independent methods each came within about 1, miles per second of the speed of light measured today. In it, he established that light travels at the same speed no matter how fast the observer moves. Even using the most precise measurements possible, the speed of light remains the same for an observer standing still on the face of the Earth as it does for one traveling in a supersonic jet above its surface. Similarly, even though Earth is orbiting the sun, which is itself moving around the Milky Way, which is a galaxy traveling through space, the measured speed of light coming from our sun would be the same whether one stood inside or outside of the galaxy to calculate it. According to astrophysicist Paul Sutter, the universe expands at roughly 68 kilometers per second per megaparsec, where a megaparsec is 3. He went on to explain that, while special relativity provides an absolute speed limit, general relativity allows for broader distances. That galaxy can have any speed it wants, as long as it stays way far away, and not up next to your face," he wrote. And neither should you. The distance light travels in the course of a year is called a light-year. A light-year is a measure of both time and distance. It is not as hard to understand as it seems. Think of it this way: Light travels from the moon to our eyes in about 1 second, which means the moon is about 1 light-second away. Sunlight takes about 8 minutes to reach our eyes, so the sun is about 8 light-minutes away. Light from the nearest star system, Alpha Centauri , is requires roughly 4. Thus, when astronomers study objects that lie a light-year away or more, they are seeing it as existed at the time that light left it, not as it would appear if they stood near its surface today. In this sense, everything we see in the distant universe is, literally, history. This principle allows astronomers to see how the universe as it looked after the Big Bang, which took place about Examining objects that are, say, 10 billion light-years away, we see them as they looked 10 billion years ago, relatively soon after the beginning of the universe, rather than how they appear today. Is the speed of light really constant? Light travels in waves, and, like sound, can be slowed depending on what it is traveling through. Nothing can outpace light in a vacuum. However, if a region contains any matter, even dust, light can bend when it comes in contact with the particles, which results in a decrease in speed. Can we travel faster than light? Science fiction loves to speculate about this, because "warp speed," as faster-than-light travel is popularly known, would allow us to travel between stars in time frames otherwise impossibly long. And while it has not been proven to be impossible, the practicality of traveling faster than light renders the idea pretty farfetched. At the speed of light, such an object has an infinite mass, while its length is 0 â€” an impossibility. Thus, no object can reach the speed of light, the theory goes. The idea of warp speed is not impossible , some say, and perhaps in future generations people will hop between stars the way we travel between cities nowadays. One proposal would involve a spaceship that could fold a space-time bubble around itself in order to exceed the speed of light. Sounds great, in theory.

6: Time-traveling photons connect general relativity to quantum mechanics â€” RT World News

The speed of light in a vacuum is , miles per second (, kilometers per second), and in theory nothing can travel faster than light. In miles per hour, light speed is, well, a lot.

References and Further Reading 1. Introduction Time travel stories have been a staple of the science fiction genre for the past century. Good science fiction stories often pay homage to the fundamentals of scientific knowledge of the time. Thus, we see time travel stories of the variety typified by H. Wells as set within the context of a Newtonian universe: By the early to mid-twentieth century, time travel stories evolved to take into account the features of an Einsteinian universe: More recently, time travel stories have incorporated features of quantum theory: Indeed, the sometimes counter-intuitive principles and effects of quantum theory have invigorated time travel stories. Bizarre phenomena like negative energy density the Casimir effect lend their strangeness to the already odd character of time travel stories. In this article, we make a distinction between time travel stories that might be possible within the canon of known physical laws and those stories that contravene or go beyond known laws. The former type of stories, which we shall call natural time travel, exploit the features or natural topology of spacetime regions. Natural time travel tends to severely constrain the activities of a time traveler and entails immense technological challenges. The latter type of stories, which we shall call Wellsian time travel, enable the time traveler more freedom and simplify the technological challenges, but at the expense of the physics. For example, in H. Also, the journey is through some different nonzero duration of time in the world. It is the latter condition that distinguishes the natural time travel story from the Wellsian time travel story. Our laws of physics do not allow travel through a nonzero duration of time in the world in a sense that will be made clearer below. Wellsian time travel stories are mortgaged on our hope or presumption that more fundamental laws of nature are yet to be discovered beyond the current horizon of scientific knowledge. Natural time travel stories can be analyzed for consistency with known physics while Wellsian time travel stories can be analyzed for consistency with logic. Finally, time travel stories implicate themselves in a constellation of common philosophical problems. Among these philosophically related issues we will address in this article are the metaphysics of time, causality, and personal identity. Definition What is time travel? This definition applies to both natural and Wellsian time travel. For example, Jane might be a time traveler if she travels for one hour but arrives two hours later in the future or two hours earlier in the past. In both types of time travel, the times experienced by a time traveler are different from the time undergone by their surrounding world. But what do we mean by the "time" in time travel? And what do we mean by "travel" in time travel? As the definition for time travel presently stands, we need to clarify what we mean by the word "time" see the next section. While philosophical analysis of time travel has attended mostly to the difficult issue of time, might there also be vagueness in the word "travel"? Our use of the word "travel" implies two places: The time of origin is plain enough: In truth, how do we conceive of a "when"â€”as a place, a locale, or a region? Different scientific ontologies result in different ideas of what travel through time might be like. Also, different metaphysical concepts of time result in different ideas of what kinds of time travel are possible. It is to the issue of time in philosophy that we now turn. Time in Philosophy How is time related to existence? Philosophy offers three primary answers to this metaphysical question: The names of these views indicate the ontological status given to time. The eternalist thinks that time, correctly understood, is a fourth dimension essentially constitutive of reality together with space. All times, past, present and future, are actual times just like all points distributed in space are actual points in space. Everything is one; the appearance of things coming to be and ceasing to be, of time passing or flowing, is simply phenomenal, not real. Objects from the past and future have equal ontological status with present objects. Thus, a presently extinct individual dodo bird exists as equably as a presently existing individual house finch, and the dodo bird and the house finch exist as equably as an individual baby sparrow hatched next Saturday. The physicist typically views the relation of time to existence in the way that the eternalist does. The life of an object in the universe can be properly shown as: This diagram shows the spatial movement in one dimension of an object through time. Many Wellsian time travel stories assume the standpoint of eternalism. The past and the present are fixed and actual; the future is only possible. Or more precisely, the future of an object holds the possibility of many different worldlines, only one of which will become actual for the object. If eternalism seems overly deterministic, eliminating indeterminacies and human free choice, then possibilism seems to retain some indeterminacy and free choice, at least as far as the future is concerned. For the possibilist, the present takes on a special significance that it does not have for the eternalist. The life of an object according to possibilism might be shown as: It should be pointed out that the necessity of illustrating the time axis with a beginning and end should not be construed as an implicit claim that time itself has a beginning and end. Some Wellsian time travel stories make use of possibilism. Stories like Back to the Future and Terminator suggest that we can change the outcome of historical events in our world, including our own personal future, through time travel. The many different possible histories of an object introduce other philosophical problems of causation and personal identity, issues that we will consider in greater depth in later sections of the article. The third view is presentism. The presentist thinks that only temporally present objects are real. Whatever is, exists now. The past was, but exists no longer; the future will be, but does not exist yet. Objects are scattered throughout space but they are not scattered throughout time. Presentists do not think that time is a dimension in the same sense as the three spatial dimensions; they say the block universe view of the eternalists and the intermediate view of the possibilists gets the metaphysics of time wrong. If eternalism has its philosophical roots in Parmenides, then presentism can be understood as having its philosophical roots in Heraclitus. Presently existing things are the only actuality and only what is now is real. Each "now" is unique: Many presentists account for the continuity of time, the timelike connection of one moment to the next moment, by appealing to the present intrinsic properties of the world Bigelow. To fully describe some of these present intrinsic properties of the world, you need past- and future-tensed truths to supervene on those properties. For example, in ordinary language we might make the claim that "George Washington camped at Valley Forge. But, according to presentism, only presently existing things are real. Thus, the proper way to understand the truth of this sentence is to translate it into a more primitive form, where the tense is captured by an operator. It is the basis for their account of persistence through time in issues like causality and personal identity. In the world of the time traveler, they do not. So, with these two senses of time, we may further clarify time travel to occur when the duration of the journey according to the personal time of the time traveler does not equal the duration of the journey in external time. Most but not all philosophy of time concerns external time see the encyclopedia entry Time. For the purpose of natural time travel, we need to examine the scientific understanding of external time and how it has changed. Newtonian Cosmology Newton argued that space, time and motion were absolute, that is, that the entire universe was a single, uniform inertial frame and that time passed equably throughout it according to an eternally fixed, immutable and inexorable rate, without relation to anything external. Natural time travel in the Newtonian universe is impossible; there are no attributes or topography of space or time that can be exploited for natural time travel stories. Only time travel stories that exceed the bounds of Newtonian physics are possible and scenarios described by some Wellsian time travel stories most notably like the one Wells himself wrote are examples of such unscientific time travel. Several philosophers and scientists objected to the notion of absolute space, time and motion, most notably Leibniz, Berkeley and Mach. Quite the contrary, time is an abstraction, at which we arrive by means of the changes of things" The Science of Mechanics, For Mach, change was more fundamental than the concept of time. We find it convenient to talk as if there were some underlying flowing substance like the water of a river that carries these changes along with it. We abstract time to have a standard measuring tool by which we can quantify change. In , Einstein published his famous paper on Special Relativity. This theory began the transformation of our understanding of space, time and motion. Special Relativity The theory of Special Relativity has two defining principles: Briefly, the principle of relativity states that the laws of physics are the same for any inertial observer. The second principle is the invariance of the speed of light. This second principle profoundly affected the model of the cosmos: The invariance of the speed of light according to Special Relativity replaces the invariance of time and distance in the Newtonian universe. Intervals of space, like length, and intervals of time and hence, motion are no longer absolute quantities. Instead of speaking of an object in a particular position independently of a particular time, we now speak of an event in which position and time are inseparable. We can relate two events with a new quantity, the spacetime interval. For any pair of events, the spacetime interval is an absolute quantity that is, has the same value for all inertial observers. To visualize this new quantity, one constructs spacetime diagrams Minkowski diagrams in which an event is defined by its spatial position usually restricted to one dimension, x and its time ct. The following figure shows a Minkowski diagram depicting the flat spacetime of Special Relativity and three different spacetime intervals, or worldlines. What are the consequences of Special Relativity for time travel? First, we lose the common sense meaning of simultaneity. Furthermore, an observer in the stationary inertial frame may determine two events to have happened simultaneously, but an observer in the second moving inertial frame would see the same two events happening at different times.

7: Light Travel Time Distance

This service calculates the total traveling time for a round trip or a multi-city trip (up to 8 cities) between cities or locations available in our World Clock, as well as display the local time for the selected cities, time zone information, and a map showing the path of the journey.

In Hindu mythology, the Mahabharata mentions the story of King Raivata Kakudmi , who travels to heaven to meet the creator Brahma and is surprised to learn when he returns to Earth that many ages have passed. After three days, he returns home to his village and finds himself years in the future, where he has been forgotten, his house is in ruins, and his family has died. When waking up he returned home but found none of the people he knew, and no one believed his claims of who he was. Prolonged sleep, like the more familiar time machine , is used as a means of time travel in these stories. An Anachronism ", written for the Dublin Literary Magazine [9] by an anonymous author in He encounters the Venerable Bede in a monastery and explains to him the developments of the coming centuries. However, the story never makes it clear whether these events are real or a dream. Alexander, son of Philip of Macedon by Alexander Veltman published in Fezziwig dance in a vision shown to Scrooge by the Ghost of Christmas Past. Other stories employ the same template, where a character naturally goes to sleep, and upon waking up find themselves in a different time. This may have been the first story to feature an alternate history created as a result of time travel. However, the mechanism borders on fantasy. An unusual clock, when wound, runs backwards and transports people nearby back in time. The author does not explain the origin or properties of the clock. Many in the scientific community believe that backward time travel is highly unlikely. Any theory that would allow time travel would introduce potential problems of causality. Some physicists, such as Novikov and Deutsch, suggested that these sorts of temporal paradoxes can be avoided through the Novikov self-consistency principle or to a variation of the many-worlds interpretation with interacting worlds. There exist exact solutions to these equations that include closed time-like curves , which are world lines that intersect themselves; some point in the causal future of the world line is also in its causal past, a situation which is akin to time travel. Whether general relativity forbids closed time-like curves for all realistic conditions is still being researched. Wormhole Wormholes are a hypothetical warped spacetime which are permitted by the Einstein field equations of general relativity. One end of the wormhole is accelerated to some significant fraction of the speed of light, perhaps with some advanced propulsion system , and then brought back to the point of origin. Alternatively, another way is to take one entrance of the wormhole and move it to within the gravitational field of an object that has higher gravity than the other entrance, and then return it to a position near the other entrance. For both of these methods, time dilation causes the end of the wormhole that has been moved to have aged less, or become "younger", than the stationary end as seen by an external observer; however, time connects differently through the wormhole than outside it, so that synchronized clocks at either end of the wormhole will always remain synchronized as seen by an observer passing through the wormhole, no matter how the two ends move around. One significant limitation of such a time machine is that it is only possible to go as far back in time as the initial creation of the machine; [20]: According to current theories on the nature of wormholes, construction of a traversable wormhole would require the existence of a substance with negative energy, often referred to as " exotic matter ". More technically, the wormhole spacetime requires a distribution of energy that violates various energy conditions , such as the null energy condition along with the weak, strong, and dominant energy conditions. However, it is known that quantum effects can lead to small measurable violations of the null energy condition, [30]: However, in a paper, Visser hypothesized that a complex " Roman ring " named after Tom Roman configuration of an N number of wormholes arranged in a symmetric polygon could still act as a time machine, although he concludes that this is more likely a flaw in classical quantum gravity theory rather than proof that causality violation is possible. If a cylinder is infinitely long and spins fast enough about its long axis, then a spaceship flying around the cylinder on a spiral path could travel back in time or forward, depending on the direction of its spiral. However, the density and speed required is so great that ordinary matter is not strong enough to construct it. A similar device might be built from a cosmic string , but none are known to exist, and it does not seem to be possible to create a new cosmic string. Physicist Ronald Mallett is attempting to recreate the conditions of a rotating black hole with ring lasers, in order to bend spacetime and allow for time travel. I can prove that to build a finite time machine, you need negative energy. One can define geometrical quantities that measure the Lorentz boost and area increase on going round these closed null geodesics. If the causality violation developed from a noncompact initial surface, the averaged weak energy condition must be violated on the Cauchy horizon. Quantum physics Main article: Quantum mechanics of time travel No-communication theorem When a signal is sent from one location and received at another location, then as long as the signal is moving at the speed of light or slower, the mathematics of simultaneity in the theory of relativity show that all reference frames agree that the transmission-event happened before the reception-event. When the signal travels faster than light, it is received before it is sent, in all reference frames. This hypothetical scenario is sometimes referred to as a tachyonic antitelephone. Nevertheless, the fact that causality is preserved in quantum mechanics is a rigorous result in modern quantum field theories , and therefore modern theories do not allow for time travel or FTL communication. In any specific instance where FTL has been claimed, more detailed analysis has proven that to get a signal, some form of classical communication must also be used. This concept is most often used in science-fiction, but some physicists such as David Deutsch have suggested that a time traveler should end up in a different history than the one he started from. The delayed choice quantum eraser experiment performed by Marlan Scully involves pairs of entangled photons that are divided into "signal photons" and "idler photons", with the signal photons emerging from one of two locations and their position later measured as in the double-slit experiment. Depending on how the idler photon is measured, the experimenter can either learn which of the two locations the signal photon emerged from or "erase" that information. Even though the signal photons can be measured before the choice has been made about the idler photons, the choice seems to retroactively determine whether or not an interference pattern is observed when one correlates measurements of idler photons to the corresponding signal photons. However, since interference can only be observed after the idler photons are measured and they are correlated with the signal photons, there is no way for experimenters to tell what choice will be made in advance just by looking at the signal photons, only by gathering classical information from the entire system; thus causality is preserved. This effect cannot be used to send any matter, energy, or information faster than light, [50] so this experiment is understood not to violate causality either. Nimtz told New Scientist magazine: Aephraim Steinberg, a quantum optics expert at the University of Toronto , Canada, uses the analogy of a train traveling from Chicago to New York, but dropping off train cars at each station along the way, so that the center of the train moves forward at each stop; in this way, the speed of the center of the train exceeds the speed of any of the individual cars. His experiment involved slow light as well as passing light through a vacuum. He generated two single photons , passing one through rubidium atoms that had been cooled with a laser thus slowing the light and passing one through a vacuum. According to Du, this implies that there is no possibility of light traveling faster than c and, thus, no possibility of violating causality. As the absence of extraterrestrial visitors does not prove they do not exist, so does the absence of time travelers not prove time travel is physically impossible; it might be that time travel is physically possible but is never developed or is cautiously used. Carl Sagan once suggested the possibility that time travelers could be here but are disguising their existence or are not recognized as time travelers. Stephen Hawking stated that this would explain why the world has not already been overrun by "tourists from the future. Some versions of the many-worlds interpretation can be used to suggest that future humans have traveled back in time, but have traveled back to the meeting time and place in a parallel universe. Time dilation Transversal time dilation. The blue dots represent a pulse of light. Each pair of dots with light "bouncing" between them is a clock. That is so, even though the clocks are identical and their relative motion is perfectly symmetric. There is a great deal of observable evidence for time dilation in special relativity [57] and gravitational time dilation in general relativity, [58] [59] [60] for example in the famous and easy-to-replicate observation of atmospheric muon decay. Time dilation is a direct consequence of the invariance of the speed of light. This can be achieved by traveling at relativistic speeds or through the effects of gravity. This is possible due to the relativity of simultaneity. However, the symmetry is broken if one clock accelerates, allowing for less proper time to pass for one clock than the other. The twin paradox describes this: General relativity treats the effects of acceleration and the effects of gravity as equivalent , and shows that time dilation also occurs in gravity wells , with a clock deeper in the well ticking more slowly; this effect is taken into account when calibrating the clocks on the satellites of the Global Positioning System , and it could lead to significant differences in rates of aging for observers at different distances from a large gravity well such as a black hole. A person at its center will travel forward in time at a rate four times that of distant observers. Philosophy of space and time Philosophers have discussed the nature of time since at least the time of ancient Greece ; for example, Parmenides presented the view that time is an illusion. Centuries later, Isaac Newton supported the idea of absolute time , while his contemporary Gottfried Wilhelm Leibniz maintained that time is only a relation between events and it cannot be expressed independently. The latter approach eventually gave rise to the spacetime of relativity. Both ends of the bar pass through the ring simultaneously in the rest frame of the ring left , but the ends of the bar pass one after the other in the rest frame of the bar right. Presentism is a school of philosophy that holds that the future and the past exist only as changes that occurred or will occur to the present, and they have no real existence of their own. In this view, time travel is impossible because there is no future or past to travel to. Alice and Bob are simultaneous observers of event O. Therefore, Alice and Bob disagree about what exists in the present, which contradicts classical presentism. Grandfather paradox A common objection to the idea of traveling back in time is put forth in the grandfather paradox or the argument of auto-infanticide. Some philosophers answer the paradoxes by arguing that it might be the case that backward time travel could be possible but that it would be impossible to actually change the past in any way, [78] an idea similar to the proposed Novikov self-consistency principle in physics. Ontological paradox Compossibility According to the philosophical theory of compossibility , what can happen, for example in the context of time travel, must be weighed against the context of everything relating to the situation. What can happen when a time traveler visits the past is limited to what did happen, in order to prevent logical contradictions. Ross argues in "Time Travel Paradoxes" [85] that in a scenario involving a physical object whose world-line or history forms a closed loop in time there can be a violation of the second law of thermodynamics. Ross uses "Somewhere in Time" as an example of such an ontological paradox, where a watch is given to a person, and 60 years later the same watch is brought back in time and given to the same character. Ross states that entropy of the watch will increase, and the watch carried back in time will be more worn with each repetition of its history. The second law of thermodynamics is understood by modern physicists to be a statistical law, so decreasing entropy or non-increasing entropy are not impossible, just improbable. Time travel in fiction Time travel themes in science fiction and the media can generally be grouped into three categories:

8: special relativity - How are light and time related? - Physics Stack Exchange

There's a speed limit of , kilometers per second (or , miles per second) for anything that travels through space-time, and light always travels the speed limit through empty space. Special Relativity also says that a surprising thing happens when you move through space-time, especially when your speed relative to other objects is.

Tweet Do the laws of nature allow for time travel? Still, what we do have to say here is certainly pertinent to the question. Take this as an elementary primer for a study of the actual physics of time travel. Our modest goal is to sketch how both forward and backward time travel are permitted by relativity theory. The prospects of forward time travel are less complex to describe and will require fewer idealizations. Backwards time travel is much more a matter of purely theoretical consideration. After a brief introduction to relativity theory, we will describe a case of time travel to the future and a case of time travel to the past; each case is consistent with the laws of relativity theory. Relativity and Minkowski Spacetime In , H. Wells penned a depiction of machine-based time travel as a serial later republished as a novella: It is a common practice to start discussions of relativity theory by introducing the idea of a frame of reference. We are brought up understanding space and time, in part, through our ordinary ways of measuring spatial properties like length e. Employing frames of reference allows one to begin thinking about relativity theory using these familiar ways of making observations about space and time. Taking such an approach leads one quickly to conclusions that show that the resulting measurements are not absolute, but are relative to a frame of reference. Length and duration turn out to be frame-dependent. Relativity theory, however, is a theory about the nature of the universe, and is notâ€”in the first instanceâ€”about frames of reference. Indeed, when it comes to the possibility of time travel, frame-relative measurements areâ€”conveniently for usâ€—pretty incidental. Insofar as the laws of relativity do permit time travel, time travel turns out to be a frame-independent phenomenon. In order to present our examples of time travel, we will introduce a coordinate system for a particular frame of reference, but we do so only to allow a simple algebraic description of the key frame-independent phenomenon. In Minkowski Spacetime, the spacetime of the Special Theory of Relativity, the time measured or experienced by a person or object moving inertially between two events is proportional to the spacetime interval between the events. The spacetime interval between two events is frame-independent. In Euclidean 3-Space, described using Cartesian coordinates, the interval between two points, x2, y2, z2 and x1, y1, z1 is defined as the square root of the sum of the squares of the separation between the points along the three spatial dimensions: This separation between two points is the same no matter the choice of the origin or any rotation of the axes for the coordinate system; this is a defining feature of Cartesian coordinate systems. The location of a point is provided by an ordered four-tuple of coordinates, each along one of four dimensions. The interval between two points, t2, x2, y2, z2 and t1,x1, y1, z1 , is not given by the separation for Euclidean 4-Space: It is given by: This interval formula is the chosen formula for the separation between two events in Minkowski spacetime. The interval value between two points holds no matter the choice of the origin or any rotation of the axes of the coordinate system; this is a defining feature of Lorentz coordinate systems. The spacetime interval, DM, given by the equation displayed above has physical significance. The interval is proportional to the amount of time that would be measured by a clock traveling along an inertial path between events located at t2, x2, y2, z2 and t1, x1, y1, z1. The correlation between the spacetime interval between two events and the time elapsed along the inertial path between them has been experimentally confirmed in numerous ways. We will mention a couple of these ways below. A Trip to the Future In order to present a case of forward time travel, we shall describe a simple example set in Minkowski spacetime. Suppose there is a civilization on a planet that includes events at 0, 0, 0, 0 and 10, 0, 0, 0 , and at all the intermediate points between these two events along the t-axis of this Lorentz coordinate system. If Tim wants to time travel to the future to witness an event at 10, 0, 0 ,0 , and if he wants to do it much sooner than the rest of his civilization, then Tim should take a different route through spacetime from 0, 0, 0, 0 to 10, 0, 0, 0 than does his civilization. To make the case a little more concrete, we assume that the separation on the t-axis between the two events corresponds to 10 years. Suppose that Tim travels away from the planet at a very high speed arriving at a nearby star at 5, 4, 0, 0. Take him to be traveling 4 light years along the x-axis and 5 years along the t-axis. Leaving immediately upon arrival at the star, Tim heads back to the planet, arriving back at the planet at 10, 0, 0, 0. It turns out that the sum of the spacetime interval from 0, 0, 0, 0 to 5, 4, 0, 0 and the interval from 5, 4, 0, 0 to 10, 0, 0, 0 is less than the interval from 0, 0, 0, 0 to 10, 0, 0, 0. This clearly is not in line with the spatial distances we see between the coordinates and the figures depicting these points in the diagram! An application of the spacetime interval formula reveals that time passes differently for Tim than it does for his civilization. The spacetime interval between 10, 0, 0, 0 and 0, 0, 0, 0 along the path of his home planet is given by: If 10 years have elapsed on the planet, then only 6 years have passed for Tim. Had he traveled at even higher speeds to and from the star, he could have gotten back in even less time. He could have witnessed the event at 10, 0, 0, 0 at an even younger age. This is not just theory. The consequence of taking different paths through spacetime on the amount of time that passes has been observed and documented often. In one of the more famous experiments, completed in , scientists J. Hafele and Richard E. Keating placed cesium beam clocks aboard a commercial airliner headed eastward around the world. The plane was flown around the world and then compared with a reference atomic time scale at rest. Upon completion of the trip, it was found that the clocks from the flight were about 59 nanoseconds behind the clock at rest, which is almost the exact value that relativity theory predicts. Confirmation also comes from the behavior of basic particles called muons. They have a short half-lifeâ€”less than two microseconds. When moving at high speeds, muons survive much longer than this short half-life would lead us to expect. With higher speeds, the particles survive longer, because they have experienced less time. For additional discussion of these and other results, see Gott , p. Has Tim time-traveled to the future? Frank Arntzenius reports being unsure about there being a clear notion of forward time travel. According to special and general relativity two clocks that travel along different world-lines from spacetime point A to spacetime point B will, almost always, measure different time intervals between A and B no matter what the structure the spacetime has â€¦ So, on a fairly natural characterization of what it is for there to be forwards time travel, forwards time travel would be ubiquitous, too ubiquitous to be interesting , p. Also see Horwich , p. We are so for the following reasons: In some ways, Tim is like Marygay of The Forever War who purchases a cruiser to use as a time machine p. That could have been done in our example by having Tim travel along a different path. But it should hardly be a surprise that, when we turn our attention from a concept born and initially revealed in science fiction to looking for instances of the concept in the pages of science, that we find some divergence. We should respect science-fiction informed thoughts about what time travel is like, but we should not demand that they all apply in order to reasonably classify a scientific phenomenon as time travel. Not all preconceptions of a phenomenon are required to be met for there to be an actual discovery of the phenomenon. A Trip to the Past Relativity theory also allows for ways to travel to the past. What we need is a wormhole time machine. To understand what a wormhole is, think about a tunnel through a mountain. Without the tunnel, we would have to travel around or over the mountain. With the tunnel, we could get to the other side much more quickly and easily, traveling a much shorter distance. Similarly, wormholes connect more ordinary regions of spacetime, thus permitting a shortcut between them. Of course, a tunnel through a mountain is not a time machine into the past. Neither, necessarily, is a wormhole. Thorne and his colleagues described a method for turning a wormhole into a time machine. There are lots of obstacles. For example, you must first find a wormholeâ€”and so far no one has. The wormhole has also got to be large enough or be made large enough for your body to fit through. You also better make sure that the wormhole will not collapse before you are done with your trip. Thorne and his colleagues describe possible methods for doing all thisâ€”none easy to put in placeâ€—but we will not concern ourselves with these practical details. For us, the focus will be on what Thorne has to say about how the nature of the spacetime permits one end of the wormhole to be later in time than the other end, thus providing a gateway to and from earlier times. To do so, we are going to simplify in one significant way. Minkowski Spacetime does not include wormholes. We would need to go beyond the Special Theory of Relativity to consider the General Theory of Relativity in order to describe a spacetime that allows for wormholes. That, in turn, would require us to bring in more difficult math than would be appropriate for this discussion. With this simplification, the characteristic of spacetime that permits one to turn a wormhole into a wormhole time machine is easy to describe. In fact, we have already covered most of what you need to know. To build our wormhole time machine, we just need to separate the mouths of a wormhole in time. How does he manage that? In keeping with our earlier example, when Tim arrives back at 10, 0, 0, 0 , only 6 years have passed for Tim though 10 years have passed for his civilization. There is the same difference in the time that has passed for the two wormhole ends that end being located at 10, 0, 0, 0. In the diagram above, though the two mouths of the wormhole are the same age at 0, 0, 0, 0 , at 10, 0, 0, 0 , the tan end of the wormhole is 4 years older than the gray end. With no change in the length of the wormhole, the two mouths of the wormhole will stay in sync: At any point during the trip, Tim could have hopped in the gray mouth, immediately exited the tan mouth, and Tim and Tom would agree about how much time had passed since Tim started his trip. Similarly, Tom could have hopped in the tan mouth of the wormhole, exited the gray mouth, and the two friends would agree about how much time had passed. So, what happens if Tom hops into the tan entrance of the wormhole at 6, 0, 0, 0? Because the ends of the wormhole are in sync, he would end up where and when 6 years had passed for Tim. So, he would immediately exit at 10, 0, 0, 0 , thus using the wormhole time machine to take a trip four years into the future of his civilization!

9: Time Travels Light

The time warp is small for everyday motion, but grows without limit as the speed of light is approached. Cosmic rays, for example, travel exceedingly close to the speed of light, and their.

Hopefully we can change that now and by the end of this read you will have a better understanding of these two topics. Even though we experience both every day, time and the speed of light usually happens without us noticing or thinking about them. So let us begin with the speed of light first if for the only reason, I just like thinking about it. Knowing the speed of light helps us in determining the age of the universe as well as understanding the great, great distances to the stars and the galaxies in the universe. Light also, using telescopes, lets us see into the distance past and shows us what the universe looked liked billions of years ago. Yes, using light we can actually see the universe billions of years ago. So what is the speed of light and how fast is it? Well, lets say I have a flashlight that was the most powerful flashlight ever made and it was bright enough so that its light over time could travel through the universe. Now, when we talk about how fast photons of light move, there is probably nothing faster than light. Now, when I turn the flashlight on you had better hang on because in one second you will travel , miles. In one second, light travels over three quarters the distance to the moon, which is To understand the distance to our moon, the Earth is miles in diameter and our moon is , away from the Earth. So we now know that light travels at , miles per second and that is a distance of more than three quarters the way to the Moon. Also in one second, light will make 60 trips between New York and Los Angeles. Being mass less, photons of light are possibly the fastest things in the universe and nothing can travel faster than light. You could not travel faster than light because if you could you would be in a time that has not yet happened. After one minute hanging onto that photon of light, you will have traveled 11,, miles. If you could hang on for one hour you will have traveled ,, miles, almost seven hundred million miles and a light hour. A light year is the distance light travels in one year. It is often rounded up to 6 trillion miles in a year or that a light year equals a distance of 6 trillion miles. A light year, a light hour and a light minute are all measurements of distance rather than time although time is an equation within this distance which I will get into a little farther into this chapter. Now when we determine the distances to the stars within our galaxy or even further to the billion other galaxies in the Universe, we are talking about distances that are very, very hard to visualize and comprehend. Even trying to picture the distance to the closest star to us, Alpha Centuari, which is 4. Saying 26 trillion miles is not something that is easily visualized. How can anyone understand these distances when you remember that one light year equals a distance of almost 6 trillion miles and you want to understand what 13 billion individual light years distance is. As far as how far in miles that is, yea right. It just makes it easier to understand when you hear 13 billion light years compared to eighteen million kazillion, seven hundred forty three quintillion, nine hundred million quadrillion, eighty eight trillion, four million billion, fifty nine million, thirty three thousand, six hundred and eighty eight miles away. Time is a weird thing when it comes to the speed of light because with the speed of light, the farther something is away from us, the more time it took those photons of light traveling through the universe to reach us for us to see. As these photons arrive for us to see, they carry with them a picture of their place of origin. In essence, the further light has traveled to us, the further back in time we are seeing. When we look at these 13 billion light year distant galaxies, we are seeing the light that left these galaxies What we see is how these galaxies looked We can actually see into the past like a time machine by looking farther and farther into the Universe. As we started out in the beginning of this chapter, when I turn the flashlight on and you hang on to that photon of light, that photon takes off and begins its journey through the Universe at a speed of thousand miles a second and 6 trillion miles a year. When we look at a galaxy 13 billion light years away from us, that photon has traveled 13 billion years at the speed of 6 trillion miles a year to reach our telescope and our eyes. The same is true when we look at a star such as Sirius, a bright star located only 8 light years away or 8 x 6 trillion miles, so its light has traveled 48 trillion miles, taking 8 years to reach us. As we look at Sirius, we are seeing it as it looked 8 years ago as it took these photons of light 8 years to reach us. We are in effect looking back in time to see how Sirius looked 8 years ago. As we look at an object in our galaxy like the Orion Nebula, which is a giant star forming gas and dust cloud containing all the elements from hydrogen to uranium, at lights years distance. When we look out of our galaxy and look at other galaxies this lets us see even further back in time as light from other galaxies have traveled millions or billions of years to reach our telescopes. By looking at far away galaxies, The record of the history of the universe is before our eyes to see and decipher. Time and light hold the proof to how the universe started and evolved. Since all the galaxies in the universe formed around the same time If we then look at galaxies whose light is 9 billion years old, we can see what the universe looked like 9 billion years ago. The same is true when we look at galaxies 8 billion light years, 7 billion light years, 5 billion light years, 1 billion light years, million light years, million lights years, 10 million lights years, and the Andromeda galaxy at 2. By looking at different distances in the universe, we can actually look into the past and see young galaxies in the early universe still in the process of forming and we can watch closer galaxies mature from light that has traveled less than Now, we can say time machines really do exist and they are called telescopes. Even when we look at something far away, say looking from shore at a ship that is about to drop under the horizon. If you were talking to someone manning a spotlight on the ship and you both counted from 3 to 0 and then your covert on the ship turns on the spotlight, it would appear to you on land, that the light was turned on exactly when your counterpart said he turned the light on. Light travels that fast and from our vantage of looking at distances from different points on Earth, everything we look at on Earth is too close and light is too quick to reach us from where it came that light seems to be instantaneous. But light is not instantaneous. Light has to leave what we are looking at and then travel to our eyes for us to see it. When you remember that light travels three quarters the way to the Moon in one second or would go around the Earth seven and a half times in one second, any distance we have on our mile diameter planet is covered quickly by light traveling at , miles per second. Our star the Sun, is 93 million miles away from us. It takes light 8 minutes to travel from the Sun to our Earth. The Sun is 8 light minutes away from us. We see the Sun as it was eight minutes ago as it took that light 8 minutes to travel from the Sun to the Earth. The deeper we pier into space, the farther back in time we see. If light was instantaneous and we saw everything in the universe as it happens, we would never be able see into the past which would mean it would be much harder, if not impossible to understand the history of our universe. Time Dilation traveling close to the speed of light This is where you have to expand your thinking somewhat. When it comes to the effects of traveling close to the speed of light, it sometimes appears to be mind-boggling when you hear some of the theories that talk about time travel and traveling the great, great distances to the stars in our galaxy and even more so to the other galaxies in the universe. The effects it has on the space travelers and to the people watching them on their home planet is something out of a science fiction novel. It is also true. These are almost like brain exercises as you try to picture their concepts. It sometimes just leaves you saying, huh? Go back and read the paragraph again if you have to. Something happens in our universe because something else happened to make that something happen. The universe is the way it is today because of all the different things that happened since the Big Bang roughly 14 billion years ago leading up to today. Everything happens because it had to happen. This is the theory everyone has heard. It says that the faster you travel, the more time slows for the traveler. This is true but only a part of the story. What does this mean? Let me give you an example. This is slightly different than the original but it represents a good example of two people seeing the same thing but with two different perspectives to what each is seeing. It begins, there are two people. One Bill , is standing on the platform of a railroad station waiting for the train to pull in. The other, Mary, is on a train coming towards the train station. The only thing abnormal about this scene is that the train on one side, the side facing the platform, is missing its side but only to anyone on the outside of the train. So again Bill on the platform can see into the train but Mary inside the train cannot see out. Now inside the train, Mary is sitting on a chair in the center of the train, against the wall on the side opposite of the train platform where Bill is standing and she is facing the platform side. As she sits, Mary is watching two people play ping pong on a table in the center of the train car. Looking at the train the player towards the back of the train is about to serve the ball towards his opponent on the side of the table towards the front of the train. He is serving in the direction the train is moving. At the same time he makes his first serve, the train is passing the train station platform. The train is moving at a speed of 90 miles an hour and traveling past the train station going to the next station. Now as the train passes Bill on the platform, his eye catches the ping pong game so both he and Mary are watching the player make his first serve. Here comes the strange part of who, what, where and when. When the player hits the ball, the ball will be moving 10 miles an hour in the direction the train is moving. As Mary watches the player hit the ball, she sees the ball move towards his opponent at a speed of 10 miles an hour. Because Mary is traveling inside the train at the trains speed, she sees the ball hit and move at 10 miles an hour. As Bill watches standing on the platform, the train is wizzing by him at 90 miles an hour. When the ball is hit he sees the ball move at miles an hour because he not only sees the ball move at 10 miles an hour, he also sees the train moving at 90 miles an hour so it appears to him that the ball is traveling miles an hour. Which one is right, Mary who sees the ball move at 10 miles an hour or Bill who sees the ball move at miles an hour. The answer is, they are both right. How can that be you ask? The answer is relativity. What they see is relative to where they are.

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