

On issue Is Faster-Than-Light Travel or Communication Possible?

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Following on from my article “On the issue of is the speed of light constant” commenting on a Physics FAQ site. The Physics FAQ site also deals with “Is Faster-Than-Light Travel or Communication Possible?” I will now comment on that. Basically – Einstein was confused and he was confusing; his influence was to confuse certain people. And those certain people have built upon this confused mess left by Einstein to make an even bigger mess. So when it comes to issues such as faster than light (FTL) they leave us a mess. I shall now untangle and straighten out as much as possible what this Physics FAQ tells us about FTL.

From Physics FAQ article “Is Faster-Than-Light Travel or Communication Possible?” [1] by Philip Gibbs it starts:

It might be thought that special relativity provides a short negative answer to this question. In actual fact, there are many trivial ways in which things can be going faster than light (FTL) in a sense, and there may be other more genuine possibilities.

me: Sounds all very vague, as per what we come to expect from the vagueness of SR (Special relativity). Actually there are some who claim FTL not possible from their belief in SR and some who believe it is possible.

On the other hand, there are also good reasons to believe that real FTL travel and communication will always be unachievable.

me: That is only just a belief from SR, and the people who think that must just be confused. SR is about adjustments of measurements to keep lightspeed constant; there is no reason why this should prevent FTL. But since Einstein was confused and confusing, it is quite easy to see why it has confused some people to think why FTL is not possible.

This article is not a full answer to the question (which no doubt will continue to be discussed in the newsgroups for the foreseeable future),

me: Not a “full answer” because SR has confused people leading them to believe different things thus creating an ongoing debate/controversy.

..but it does cover some of the more common points that are repeatedly made.

It is sometimes objected that "*they said no-one would ever go faster than sound and they were wrong. Now they say no-one will ever go faster than light...*" Actually it is probably not true that anybody said it was impossible to go faster than sound.

me: I note the word “probably”; it means that the author is not sure.

It was known that rifle bullets go faster than sound long before an aircraft did. The truth is that some engineers once said that *controlled flight* faster than sound might be impossible, and they were wrong about that.

me: Some Engineers “might” have thought that, after all there were technical problems to solve.

FTL travel is a very different matter. It was inevitable that someone would one day succeed in flying faster than sound, once technology got around the problems.

me: That’s looking back at things in retrospect. If we were living before first supersonic flight and looking at the technical problems with it then we might not have seen a solution.

It is not inevitable that one day technology will enable us to go faster than light.

me: That is just stating a belief without any justification. There are of course technical problems with building a craft to go FTL, we might not be able to see how to do it, we might conclude it is beyond our technology to do it. But it not being possible for our technology does not mean it might it is impossible for some future technology.

Relativity has a lot to say about this. If FTL travel or FTL communication were possible, then causality would probably be violated and some very strange situations would arise.

me: There is no connection between causality violation and FTL in the Newtonian physics perspective. This is where some SRists have confused themselves. Adjusting measurements to have lightspeed fixed at some value c does not mean that no speeds greater than c are possible. And if there are speeds greater than c and that messes up our clocks (which are set for c) - then that just means our clocks are messed up, not that causality has been violated.

me: There is another sense of FTL – that after the FTL of Newtonian physics when adjusted to being sublight in SR there still remains FTL in the SR perspective. This second type of FTL is probably what the SRists are thinking about when they talk about causality violation. But

in the first type of FTL there is no causality violation. I shall continue for the time being dealing with the first type of FTL.

First we will cover the trivial ways in which things can go FTL. These points are mentioned not because they are interesting, but because they come up time and time again when FTL is being discussed, and so they are necessary to deal with. Then we will think about what we mean by non-trivial FTL travel/communication and examine some of the arguments against it. Finally, we will look at some of the more serious proposals for real FTL. Many of these things are discussed in more detail elsewhere in the FAQ and hyper-links are provided. The sections are numbered so that they can be referred to individually.

me: So onto trivial FTL:

1. Cherenkov Effect

One way to go faster than light is to make the light slow down! Light in vacuum travels at a speed c which is a universal constant (see the FAQ entry Is the speed of light constant?)

me: That FAQ dealt with in another article by me

but in a dense medium such as water or glass, light slows down to c/n where n is the refractive index of the medium (1.0003 for air, 1.4 for water). It is certainly possible for particles to travel through air or water at faster than the speed of light in the medium, and *Cherenkov radiation* is produced as a result. See the FAQ entry Is there an equivalent of the sonic boom for light?

When we discuss moving faster than the speed of light, we are really talking about exceeding the speed of light in vacuum c (299,792,458 m/s). The Cherenkov effect is thus not considered to be a real example of FTL travel.

me: Cherenkov effect in other words has only been measured/observed in mediums like air and water and not in near-vacuum of space. What we really need to know is whether attempts to observe it in near-vacuum have been made.

2. Third Party Observers

If a rocket A is travelling away from me at $0.6c$ in a westerly direction, and another B is travelling away from me at $0.6c$ in an easterly direction, then the total distance between A and B as seen in my frame of reference is increasing at $1.2c$. An apparent relative speed greater than c can be observed by a third person in this way.

me: Ok

However, this is not what is normally meant by relative speeds.

me: Relevant word is “normally”, in other words it can be used to mean relative speeds. These people who don’t “normally” use it that

way, I propose are peculiar; and the reason they are peculiar is that they are trying to go by SR and it has confused them.

The true speed of rocket *A* relative to rocket *B* is the speed at which an observer in rocket *B* observes his distance from *A* to be increasing.

me: The use of the term “true” is peculiar, what is the relative speed as it was earlier measured as $1.2c$ supposed to be if it was also not “true”. These SRists are trying to get confused over the word “true.”

The two speeds must be added using the relativistic formula for addition of velocities.

me: And that does not give $1.2c$ which was the relative speed of earlier, so the relativistic addition formula is trying to confuse things.

(See the FAQ entry [How do You Add Velocities in Special Relativity?](#)) In this case the relative speed is actually about $0.88c$, so this is not an example of FTL travel.

me: And this $0.88c$ is not the speed observed earlier to be $1.2c$, so they have confused themselves. Now they are trying to pretend the speed $1.2c$ is not $1.2c$ but instead this $0.88c$, that shows you have confused these SRists get. Of course their method is to set their measuring instruments so that speed of light is c , so this is what the relativistic velocity formula is all about, when they get some speed greater than c such as the $1.2c$ they try then to adjust things and scale it down to less than c , that's where they get their $0.88c$ from. But adjusting their instruments in this way as per what SR wants does not stop the speed $1.2c$ being less than c as viewed from a Newtonian physics which is not going to bodge its measurements the SR way. So from Newtonian physics $1.2c$ is $1.2c$ and we have greater than c , FTL in other words.

3. Shadows and Light Spots

Think about how fast a shadow can move. If you project the shadow of your finger using a nearby lamp onto a distant wall and then wag your finger, the shadow will move much faster than your finger. If your finger moves parallel to the wall, the shadow's speed will be multiplied by a factor D/d where d is the distance from the lamp to your finger, and D is the distance from the lamp to the wall. The speed can even be much faster than this if the wall is at an angle to your finger's motion. If the wall is very far away, the movement of the shadow will be delayed because of the time it takes light to get there, but the shadow's speed is still increased by the same ratio. The speed of a shadow is therefore not restricted to be less than the speed of light.

me: Ok and for this is as per Newtonian physics and we have FTL for the shadow. What the author is getting confused about is – that he has just explained this by Newtonian physics, and if he were genuinely now dealing with SR then SR would be telling him to adjust the measurements so that the shadow was not moving FTL.

Others things that can go FTL include the spot of a laser that has been aimed at the surface of the Moon. Given that the distance to the Moon is 385,000 km, try working out the speed of the spot if you wave the laser at a gentle speed. You might also like to think about a water wave arriving obliquely at a long straight beach. How fast can the point at which the wave is breaking travel along the beach?

me: Still thinking in Newtonian physics – the light spot follows same physics earlier as the shadow, and author is forgetting the SR adjustments.

This sort of thing can turn up in Nature; for example, the beam of light from a pulsar can sweep across a dust cloud. A bright explosion emits an expanding spherical shell of light or other radiation. When this shell intersects a surface, it creates a circle of light which expands faster than light. A natural example of this has been observed when an electromagnetic pulse from a lightning flash hits an upper layer of the atmosphere.

me: Exactly, all Newtonian physics.

These are all examples of things that can go faster than light, but which are not physical objects.

me: Now the author is getting confused. The light spot earlier had faster than light (FTL) and we would think that were a physical entity, and shadows are created by light (light can cancel other light out (interference) and shadow as absence of light) so in a sense is physical also. But the author is so confused over SR that now wants to get confused over “physical entities.”

It is not possible to send information faster than light on a shadow or light spot, so FTL communication is not possible in this way.

me: This claim is just nonsense. Newtonian physics would never make such a claim. Either the author now is totally confused over Newtonian physics and does not realise that they were talking up to this point in Newtonian physics terms or they totally confused about SR. i.e. they are confused in SR and that confusion as led them to be confused about Newtonian physics also. From the Newtonian physics perspective it's easy- the light that travels to make up the dot travels there at c , but the spot can move FTL. So information from light source to spot is at c , but the information from dot old position to new position is FTL when it's travelling FTL. But of course SR would readjust this for no good reason and set everything back to less than and equal to c .

This is not what we mean by faster than light travel, although it shows how difficult it is to define what we really do mean by faster than light travel.

me: Just means the author has confused himself over FTL, because by Newtonian physics perspective it is what we would call FTL.

4. Rigid Bodies

If you have a long rigid stick and you hit one end, wouldn't the other end have to move immediately? Would this not provide a means of FTL communication?

me: Not necessarily – what is happening is that the atoms in the rod are set vibrating and that vibration is being transmitted to the rest of the atoms in the rod; that speed of transmission of vibrations need not be FTL.

Well, it would *if* there were such things as perfectly rigid bodies.

me: Now talking about an idealised case. If we idealised things we could conceive of the vibrations being instantaneously transmitted from the end of the rod that was hit to the other end. But in practice – we don't get the idealised case and the vibrations would not be transmitted instantaneously.

In practice the effect of hitting one end of the stick propagates along it at the speed of sound in the material; this speed depends on the stick's elasticity and density.

me: Exactly, not as per the idealised case of a perfectly rigid body.

Relativity places an absolute limit on material rigidity in such a way that the speed of sound in the material will not be greater than c .

me: It is often the case that the word “relativity” is misused, when the word “relativity” is used often it is meant to mean “special relativity”, but the word “special” has been forgotten to be added. The term “relativity” can apply to things other than “special relativity.” In this particular sentence I will take it to mean he is talking about special relativity (SR), and so when he says “... the speed of sound in the material will not be greater than c .” He is thinking in terms of SR when he says that, and from SR the adjustments of measurements are made to set speed down to less than or equal to c . So if the sound were travelling FTL as per Newtonian physics, then by SR it would be adjusting that speed to be less than c .

The same principle applies if you hold a long string or rod vertically in a gravitational field and let go of the top end. The point at which you let go will start to move

immediately, but the lower end cannot move until the effect has propagated down the length at the speed of sound in the material.

me: Now he is talking about a gravity situation. Going by Einstein this would then be General relativity (GR) not the earlier case of SR. So it's not "exactly" the same. He now deals with GR whereas earlier he dealt with SR. But granted that and granted what he said in earlier article on "speed of light" he takes the version of GR as being to adjust speeds to be less than or equal to c . (and note – he accepted that there was another version of GR where did not adjust the speed of light.)

It is difficult to formulate a general theory of elastic materials in relativity,

me: Exactly because of the adjustments to measurements that Einstein's relativity wants it confuses a lot of people.

but the general principle can be illustrated with Newtonian mechanics.

me: Yes, things are much easier understood from a Newtonian physics perspective.

The equation for longitudinal motion in an ideal elastic body can be derived from Hooke's law. In terms of the mass per unit length p and Young's modulus of elasticity Y , the longitudinal displacement X satisfies a wave equation (see for example Goldstein's "Classical Mechanics"):

$$p \frac{d^2X}{dt^2} - Y \frac{d^2X}{dx^2} = 0$$

me: I just want to point out that we are dealing with an idealised math model here.

Plane wave solutions travel at the speed of sound s where $s^2 = Y/p$. This wave equation does not allow any causal effect to propagate faster than s .

me: Ok, but still within the context of an idealised scenario.

Relativity therefore imposes a limit on elasticity: $Y < pc^2$.

me: Author says "relativity" again when must really mean SR. Well given what SR does about adjusting measurements then this "limit" is just what comes from it. If went by Newtonian physics there is no limit, and the "limit" that SR imposes is just a bodge created by the way SR adjusts measurements.

In practice, no known material comes anywhere near this limit. Note that even if the speed of sound is near c , the matter does not necessarily move at relativistic speeds. But how can we know that no material can possibly exceed this limit? The answer is that all materials are made of particles whose interactions are governed by the standard model of particle physics, and no influence faster than light can propagate in that model (see the section on Quantum Field Theory below).

me: Quantum field theory section will be dealt with anon. Anyway, given SR's way of making adjustments to measurements and imposing the "limit" stated here, there are some theorists that imagine materials that violate even that "limit".

So although there is no such thing as a rigid body, there *is* such a thing as rigid body motion; but this is another example in the same category as the shadows and light spots described above which do not give FTL communication.

me: As dealt with both this type of FTL and previous according to Newtonian physics do actually give FTL. Doing the adjustments required by SR just confuses things.

5. Phase Velocity

Look at this wave equation:

$$\frac{d^2u}{dt^2} - c^2 \frac{d^2u}{dx^2} + w^2 u = 0$$

This has solutions of the form:

$$u = A \cos(ax - bt)$$

$$c^2 a^2 - b^2 + w^2 = 0$$

These solutions are sine waves propagating with a speed

$$v = b/a = \sqrt{c^2 + (w/a)^2}$$

me: once again I would like to point out - this is an idealised math model.

But this is faster than light, so is this the equation for a tachyon field?

me: From the Newtonian physics perspective accepting the conditions that this is an idealised scenario then the answer would be this is FTL. As to the issue of is it "tachyons" is more difficult, because the way that "tachyons" are defined is usually in of Einstein's relativity not

Newtonian physics, and Einstein's relativity has confused many people.

(See the paragraph on tachyons below).

me: I think the author has his article in the wrong order and so bring up what he says about "tachyons".

Tachyons are hypothetical particles that travel faster than light locally.

me: Author uses word "locally" and in this article has not explained what "locally" means. For the sake of argument I will just take it to mean for now that it means SR being applied. So he is talking about tachyons in context of SR.

Their mass must take on imaginary values (i.e. to do with the square root of -1) to be able to do so, but they have real-valued energy and momentum.

me: This is all the type of what the math looks like in SR context.

Sometimes people imagine that such FTL particles would be impossible to detect, but there is no reason to think so. Shadows and spotlights suffice to show that there is no logic in this suggestion, because *they* can certainly go FTL and still be seen.

me: Earlier I pointed out the author's confusion on the issue of information. In the previous cases he mistakenly believed information was not travelling FTL. So he has two types of FTL – one where information gets transferred (call it information-FTL) and another where information does not get transferred (call it non-information FTL). In the context of tachyons it would be helpful to know if the author believed it was information-FTL or non-information-FTL. But I suspect the author is totally confused by SR on this issue.

No tachyons have definitely been found and most physicists doubt their existence.

me: This is because I suspect – physicists have allowed themselves to be confused by Einstein's relativity and can't make sense of the relevant experiments.

There has been a claim that experiments to measure neutrino mass in tritium beta decay indicated that the neutrinos were tachyonic. ; while this is very doubtful, it is not entirely ruled out.

me: Author in other words saying not sure, and thinks others are not sure. I say this is result of Einstein confusing them.

Tachyon theories have problems

me: They definitely do when based upon the confusion created by Einstein's relativity

because, apart from the possibility of causality violations,

me: I dealt with this earlier – Einstein’s relativity has confused people on the issue of FTL over the issue of causality.

they destabilise the vacuum.

me: Probably talking about creation of particles from nothingness due to quantum fluctuations in a vacuum; yet another area where Einstein has confused things.

It may be possible to get around such difficulties--but then we would not be able to use tachyons for the kind of FTL communication that we would like.

me: The word “maybe” indicates the author is not sure. It highlights how Einstein has confused things. The author is not sure whether tachyons give information-FTL.

The truth is that most physicists consider tachyons to be a sign of pathological behaviour in field theories,

me: The word “pathological” means diseased (or mentally diseased). This “disease” in physics was introduced by Einstein. Einstein’s relativity is the disease, it introduced a complicated way of doing things that has confused people, and it’s just far easier to back to Newtonian physics.

and the interest in them among the wider public stems mostly from the fact that they are used so often in science fiction.

me: It makes for some plots for entertaining science fiction.

me: Back from tachyons: Referring to: $v = b/a = \sqrt{c^2 + (w/a)^2}$

No, it is the usual relativistic equation for an ordinary particle with mass!

me: i.e. saying the equation $v = b/a = \sqrt{c^2 + (w/a)^2}$ is not dealing with a tachyon but instead with an ordinary particle. he uses the word “relativistic” the word “special” has been omitted, when the word “relativistic” is used it is often implied that it means SR. So he thinks it a SR equation, that is actually incorrect everything up to it has been Newtonian physics. For it to be SR then suitable boding with adjusting of measurements has to be made. As it stands at the moment unaltered by SR, it is Newtonian physics and allows greater than c.

me: What the author now does with this Newtonian equation is to try to bodge it to fit SR way of doing things.

The paradox is resolved

me: No paradox has so far been stated. The equation is Newtonian physics and it allows FTL, but since the author believes FTL not allowed by his misunderstanding of SR he now thinks it is a paradox. Anyway, proceeding:

by distinguishing this speed, known as the "phase velocity" v_{ph} , from another speed known as the "group velocity" v_{gr} , where

$$v_{ph} v_{gr} = c^2$$

If a wave solution exhibits frequency dispersion it will take the form of a wave packet that travels at the group velocity--which will be less than c . Only its wave trains travel at the phase velocity. It is only possible to send information with such a wave at the group velocity, so the phase velocity is yet another example of a speed faster than light that cannot carry a message.

me: It is just a false claim saying phase velocity can't carry information. Newtonian physics has no difficulty with it. Yet another example of letting SR confuse things. If we went by SR it would be another case of having to bodge things to get phase velocity below c .

6. Superluminal Galaxies

If something is coming towards you at nearly the speed of light and you measure its apparent speed without taking into account the diminishing time it takes light to reach you from the object, you can get an answer that is faster than light. This is an optical illusion, and is not due to the object's moving at FTL. See the FAQ Apparent Superluminal Velocity of Galaxies.

me: Really it's just another case of the shadow and light dot which was dealt with earlier, but now it's regarding astronomical observations of galaxies. Quite hilarious really – there is a frame of reference where speed is FTL (in context of Newtonian physics), but because Einstein has so confused things then they (SRists) want to deny observations or at least be confused by observations.

7. Relativistic Rocket

A controller based on Earth is monitoring a space ship moving away at a speed $0.8c$. According to the theory of relativity, he will observe a time dilation that slows the ship's clocks by a factor of $5/3$, even after he has taken into account the Doppler shift of signals coming from the space ship. If he works out the distance moved by the ship divided by the time elapsed as measured by the onboard clocks, he will get an answer of $4/3 c$. He infers from this that the ship's occupants determine themselves to be traversing the distances between stars at speeds greater than the speed of light when measured with their clocks. From the point of view of the occupants their clocks undergo no slowing; rather, they maintain that it is the *distance* between the stars

which has contracted by a factor of $5/3$. So they also agree that they are covering the known distances between stars at $4/3 c$.

This is a real effect which in principle could be used by space travellers to cover very large distances in their lifetimes. If they accelerate at a constant acceleration equal to the acceleration due to gravity on Earth, they would not only have a perfect artificial gravity on their ship, but would also be able to cross the galaxy in only about 12 years of their own "proper time": that is, they would age 12 years during the journey. However, this is not true FTL travel. The effective speed calculated used the distance in one reference frame and the time in another. This is no way to calculate a speed. Only the occupants of the ship benefit from this effective speed. The controller will not measure them to be travelling large distances in his own lifetime.

me: Just typical SR confused way of looking at things from SR perspective – time intervals and lengths are different from different frames. Still best to go by Newtonian physics then don't have this mess.

8. Speed of Gravity

Some people have argued that the speed of gravity in a gravitationally bound system is much greater than c or even infinite. In fact, gravitational effects and gravitational waves travel at the speed of light c . See the articles Does Gravity Travel at the Speed of Light? and What is Gravitational Radiation? for the explanation.

me: This deserves another article about the speculations at what speed gravity might propagate. But not really relevant to the rest of FTL which is being discussed, so I pass. .

9. EPR Paradox

In 1935 Einstein, Podolsky, and Rosen published a thought experiment that seemed to produce a paradox in quantum mechanics, as well as demonstrating that it was incomplete. Their argument used the fact that there can be an apparent instantaneous interaction in the measurement of two separated particles that have been prepared in a certain "entangled" manner. Einstein called it "spooky action at a distance". It has been shown by Eberhard that no information can be passed using this effect; so there is no FTL communication, but the paradox is still very controversial. See the FAQ article The EPR Paradox and Bell's Inequality for more details.

me: Einstein disagreed with Quantum mechanics and tried to point out problems with it. There is a similar issue in Quantum mechanics as regards FTL; if we view it from a Newtonian physics perspective then FTL is allowed. To overcome it being allowed, there are the certain people who want to get confused over the word "information"; and that confusion they try to generate I dealt with earlier.

10. Virtual Photons

In quantum field theory forces are mediated by "virtual particles". The Heisenberg Uncertainty Principle allows these virtual particles to move faster than light. However, virtual particles are not called "virtual" for nothing. They are only part of a convenient mathematical notation, and once again, no real FTL travel or communication is possible.

me: Quantum field theory seeks to incorporate SR, so the mess that has so far been presented as from SR is still relevant in the Quantum field theory scenario.

11. Quantum Tunnelling

Quantum Tunnelling is the quantum mechanical effect that permits a particle to pass through a barrier when it does not have enough energy to do so classically. You can do a calculation of the time it takes a particle to tunnel through such a barrier. The answer you get can come out less than the time it takes light to cover the distance at speed c . Does this provide a means of FTL communication? [2]

The answer must surely be "No!"--otherwise our understanding of QED is very suspect.

me: QED is very suspect, because it incorporates a lot of Einstein's relativity mess.

Yet a group of physicists have performed experiments that seem to suggest that FTL communication by quantum tunneling is possible. They claim to have transmitted Mozart's 40th Symphony through a barrier 11.4cm wide at a speed of $4.7c$. Their interpretation is, of course, very controversial. Most physicists say this is a quantum effect where no *information* can actually be passed at FTL speeds. If the effect is real it is difficult to see why it should not be possible to transmit signals into the past by placing the apparatus in a fast-moving frame of reference. [3]

Terence Tao has pointed out that apparent FTL transmission of an audio signal over such a short distance is not very impressive. The signal takes less than 0.4 ns to travel the 11.4 cm at light speed, but it is quite easy to anticipate an audio signal ahead of time by up to 1000 ns simply by extrapolating the signal waveform. Although this is not what is being done in the above experiments, it does illustrate that the experimenters will need to use a much higher frequency random signal, or transmit over much larger distances, if they are to demonstrate FTL information transfer convincingly.

me: Based upon it so far, FTL was demonstrated. The author's request for wanting "convincingly" is just trying to put up blocks. Experiments just need to be repeated.

The likely conclusion is that there is no real FTL communication taking place, and that the effect is another manifestation of the Heisenberg Uncertainty Principle.

me: FTL is taking place from a Newtonian perspective, but we still have the SR way of doing things and if bodged it SR way with its adjustments then it would confuse the FTL issue again.

12. Casimir Effect

The Casimir Effect describes the fact that a very small but measurable force exists between two uncharged conducting plates when they are very close together. It is due to the existence of vacuum energy (see the FAQ article on the Casimir Effect). A surprising calculation by Scharnhorst suggests that photons travelling across the gap between the plates in the Casimir Effect must go faster than c by a very very small amount (at best 1 part in 10^{24} for a 1 nanometre gap.) It has been suggested that in certain cosmological situations, such as in the vicinity of cosmic strings if they exist, the effect could be much more pronounced. However, further theoretical investigations have shown that, once again, there is no possibility of FTL communication using this effect. [4]

me: There being “no possibility” means someone has realised that it can be bodged by SR.

13. Expansion of the Universe

According to Hubble's Law, two galaxies that are a distance D apart are moving away from each other at a speed HD , where H is Hubble's constant. So this interpretation of Hubble's Law implies that two galaxies separated by a distance greater than c/H must be moving away from each other faster than the speed of light.

me: That would be a Newtonian physics setup.

Actually, the modern viewpoint describes this situation differently: general relativity takes the galaxies as being *at rest* relative to one another, while the space between them is expanding.

me: As per previous article on GR, the author has his version of GR as adjusting measurements to keep lightspeed as constant. So from his version of GR, the Newtonian physics is being adjusted.

In that sense, the galaxies are not moving away from each other faster than the speed of light; they are not moving away from each other at all! This change of viewpoint is not arbitrary; rather, it's in accord with the different but very fruitful view of the universe that general relativity provides.

me: As per my article on GR – we can still do the things by Newtonian physics.

So the distance between two objects can be increasing faster than light because of the expansion of the universe, but this does not mean, in fact, that their relative speed is faster than light.

me: Earlier dealt with the bodge that Einstein's relativity makes in regards to velocity addition in context of SR, what is being referred to here is the same type of bodge now being extended to GR.

As was mentioned above, in special relativity it is possible for two objects to be moving apart by speeds up to twice the speed of light as measured by an observer in a third frame of reference.

me: And that was bodged as highlighted earlier.

In general relativity even this limit can be surpassed, but it will not then be possible to observe both objects at the same time.

me: Author is now just getting confused, if we go by what he treats GR as- adjustments of speeds to be less than or equal to c ; then that's still all that's going on.

Again, this is not real faster than light travel; it will not help anyone to travel across the galaxy faster than light.

me: From Newtonian perspective it is FTL.

All that is happening is that the distance between two objects is increasing faster when taken in some cosmological reference frame.

me: I think the author missed out " c ". I think he meant to say – "...distance between two objects is increasing faster [than c] when taken in some cosmological reference frame." Anyway, never mind.

14. The Moon revolves round my head faster than light!

Stand up in a clear space and spin round. It is not too difficult to turn at one revolution each two seconds. Suppose the Moon is on the horizon. How fast is it spinning round your head? It is about 385,000 km away, so the answer is 1.21 million km/s, which is more than four times the speed of light! It might sound ridiculous to say that the Moon is going round your head when really it is you who is turning, but according to general relativity all co-ordinate systems are equally valid, including rotating ones.

me: According to relativity principle – motion is relative to frame of reference; so relative to the person spinning around, can treat his frame of reference as the moon spinning round. Einstein's relativity gets that

right. It's just the other things like its adjustments that it wants to make with setting lightspeed as c that causes all the mess.

So isn't the Moon going faster than the speed of light?

me: The answer is yes from a Newtonian perspective of relative motion. SR and GR then mess things with its adjustments.

This is quite difficult to account for.

me: I just answered it very easily.

What it comes down to is the fact that velocities in different places cannot be compared directly in general relativity.

me: Because of the adjustments that Einstein's relativity wants to make on measurements.

Notice that the Moon is not overtaking any light in its own locality. The speed of the Moon can only be compared to the speeds of other objects in its own local inertial frame.

me: All of this is just trying to bodge things to fit to Einstein's relativity; when the observations don't fit Einstein's relativity then further complications have to be added to confuse things.

Indeed, the concept of speed is not a very useful one in general relativity,

me: Exactly, the adjustments required by Einstein's relativity means that things like the meaning of "speed" have to be messed up.

and this makes it difficult to define what "faster than light" means.

me: Yes when in the context of Einstein's relativity. But in the context of Newtonian physics it's easy.

Even the statement that "the speed of light is constant" is open to interpretation in general relativity.

me: Yes, that's why the adjustments that Einstein's relativity wants end up being ambiguous.

Einstein himself, on page 76 of his book "Relativity: the Special and the General Theory", wrote that the statement cannot claim unlimited validity. When there is no absolute definition of time and distance it is not so clear how speeds should be determined.

me: Yes he was confused, and those who followed him were confused by it. That's why it's so much easier to just go back to Newtonian physics.

Nevertheless, the modern interpretation is that the speed of light is constant in general relativity

me: And that makes it a different general relativity than the one Einstein was talking about.

and this statement is a tautology given that standard units of distance and time are tied together using the speed of light.

me: Yes dealt with in last article- just adjusting time and distance measurements to conform to a mess.

The Moon is given to be moving slower than light because it remains within the "future light cone" propagating from its position at any instant.

me: Yes under Einstein's relativity – things are adjusted to be a mess like that.

Relativity Arguments Against FTL Travel

15. What Does "Faster Than Light" Mean?

The cases given so far only demonstrate how difficult it is to pin down exactly what we mean by FTL travel or communication.

me: in the context of Einstein's relativity those concepts are turned into a mess. In Newtonian physics – things are much clearer.

If we do not include things such as moving shadows, then what exactly do we mean by FTL?

me: In the context of Einstein's relativity it means that you have to adjust the measurements to remove what Newtonian physics would claim as FTL.

In relativity there is no such thing as absolute velocity, only relative velocity;

me: By relativity might mean SR or GR. But it's the same on this as Newtonian-Galileo relativity.

but there is a clear distinction between "world lines" that are "timelike", "lightlike", and "spacelike". By "world line" we mean a curve traced out in the four dimensions of space-time. Such a curve is the set of all events that make up the history of a particle. If a world line is spacelike then it describes something moving faster than light.

me: Yes – Einstein's relativity is messing things up. In the context of Einstein's relativity if there was still FTL in it after Newtonian physics

FTL was adjusted to being velocity c or less, then this extra FTL would I think be causality violation.

So there is a clear meaning of what is meant by a "faster than light" speed which does not depend on the existence of third-party observers.

me: Yes Einstein messed things up.

But what do we mean by an "object" if we don't want to include shadows? We could define an object to be anything that carries energy, charge, spin, or information; or perhaps just that it must be made of atoms, but there are technical problems in each case.

me: The "technical problems" are if you are working within context of Einstein's relativity then the concepts have been messed up.

In general relativity energy cannot be localised, so we had better avoid using energy in our definition.

me: Newtonian physics can quite easily deal with energy; just Einstein's relativity messing things up again.

Charge and spin can be localised, but not every object need have charge or spin.

me: this word "localised" is being used to try to cope with the mess that Einstein's relativity has of handling things.

Using the concept of information is better but tricky to define,

me: The concept "information" also messed up in Einstein's relativity.

and sending information faster than light is really just FTL communication--not FTL travel.

Another difficulty is knowing whether an object seen at A is the same as the one that was earlier seen at B when we claim that it has travelled across the gap faster than light.

me: Yes that is Quantum mechanics issue, and by Copenhagen interpretation it was decided that if a particle was observed at one location and something similar was observed later at another location then would not assume it was the same particle. But that's all philosophising about interpreting observations in different ways.

Could it not be a duplicate? It could even be argued that FTL communication makes FTL travel possible, because you can send the blueprint for an object FTL as advance information, and then reconstruct the object--although not everyone would accept such teleportation as FTL travel.

me: Teleportation is being worked on, but nowhere near enough a level to be able to answer such a question.

The problems of specifying just what we mean by FTL are more difficult in general relativity.

me: Yes because Einstein left us a mess and as noted Einstein's GR is different to what you call the modern GR. So what would be specified as FTL in one version of GR is not necessarily what FTL would be in the other version.

A valid form of FTL travel may mean distorting space-time (e.g. making a worm hole) to get from A to B without going on a spacelike curve locally. There is a distinction between going faster than light *locally* and getting from A to B faster than light *globally*. When a gravitational lens bends the light coming from a distant galaxy asymmetrically, the light coming round the galaxy on one side reaches us later than light that left at the same time and went round the other side. We must avoid a definition of FTL travel that says a particle going from A to B gets there before light that has made the same journey along a lightlike geodesic. This makes it very difficult, perhaps impossible, to define global FTL travel unambiguously.

me: Yes, unable to define "unambiguously". Einstein's relativity has messed things up to be ambiguous.

If you were expecting me to finish this section with a precise definition of what is meant by FTL travel and FTL communication, I am afraid I must disappoint you! The above difficulties are insurmountable.

me: Only "insurmountable" when building upon the context of Einstein's relativity that demands a continual ongoing process of messing things up.

Nonetheless, you will probably recognise the real thing when confronted with it now that I have given some examples of what would not be FTL travel.

me: We can recognise FTL more easily by abandoning Einstein's relativity and going back to Newtonian physics.

16. The Infinite-Energy Argument

When Einstein wrote down his postulates for special relativity, he did not include the statement that you cannot travel faster than light.

me: Yes, it was a later add-on.

There is a misconception that it is possible to derive it as a consequence of the postulates he did give. Incidentally, it was Henri Poincare who said "Perhaps we must construct a new mechanics [...] in which the speed of light would become an

impassable limit." That was in an address to the International Congress of Arts and Science in 1904--before Einstein announced special relativity in 1905.

me: The relevant word was "perhaps"; perhaps not. Whether we should – has not been addressed in proper debate as far as I know; instead certain people have just blundered on regardless and assumed doing it that way.

It is a consequence of relativity that the energy of a particle of rest mass m moving with speed v is given by

$$E = mc^2 / \sqrt{1 - v^2/c^2}$$

me: Again with the word "relativity" when he means SR.

As the speed approaches the speed of light, the particle's energy approaches infinity.

me: Yes in SR.

Hence it should be impossible to accelerate an object with rest mass to the speed of light;

me: That is a misunderstanding of SR. What SR deals with is a mathematical idealisation, a math model and a math model has a range of applicability. Since the range of applicability of SR has not been pointed out, such claims as this are just false; and not genuinely based on SR.

also, particles with zero rest mass must always move at exactly the speed of light,

me: Zero rest mass particles are just another bodge added to SR to try to handle the mess it makes.

since otherwise they would have no energy.

me: More mess

This is sometimes called the "light speed barrier", but it is very different from the "sound speed barrier".

me: Yes because the "lightspeed barrier" is built on a mess of misunderstandings of SR.

As an aircraft approaches the speed of sound it starts to feel pressure waves which indicate that it is moving close to the speed of sound, and before the existence and effects of these waves were well understood, they destroyed several aircraft in the mid 20th century; hence the old name of sound "barrier". In fact, with more thrust and the right aerodynamics, an aircraft can certainly pass through the sound barrier.

me: Ok

The situation is different for light. As the light speed barrier is approached (in a perfect vacuum) there are no such waves according to relativity (destructive or otherwise).

me: Again with the “relativity” when probably means SR.

Moving at $0.999c$ is just like standing still with everything rushing past you at $-0.999c$. Particles are routinely pushed to these speeds and beyond in accelerators, so the theory is well established. Trying to attain the speed of light in this way is a matter of chasing something that is forever just out of your reach.

This explains why it is not possible to exceed the speed of light by ordinary mechanical means.

me: It does not; it's just the mess that SR makes as explained.

However, it does not in itself rule out FTL travel. It is really just one way in which things cannot be made to go faster than light, rather than a *proof* that there is no way to do so. Particles are known to decay instantly into other particles which fly off at high speed. It is not necessary to think in terms of the particles' having been accelerated, so how could we say that they could not go faster than light? What about the possibility of particles that might *always* have been moving faster than light, and which might be used to send information if they can be detected without ever slowing down to less than the speed of light? Even if such "tachyons" don't exist (and we don't believe that they do exist), there may be ways of moving matter from *A* to *B* faster than light is able to travel from *A* to *B* by the usual route, but without anything having to go at a FTL speed locally. See the paragraph on tachyons below.

17. Quantum Field Theory

Except for gravity, all physical phenomena are observed to comply with the "Standard Model" of particle physics.

me: The Standard Model itself has been bodged to a large extent to try to fit what is observed with particles.

The Standard Model is a relativistic quantum field theory which incorporates the nuclear and electromagnetic forces as well as all the observed particles. In this theory, any pair of operators corresponding to physical observables at space-time events separated by a spacelike interval "commute" (i.e. their order can be reversed).

me: Yes the SR part of it has made it a confusing mess.

In principle, this implies that effects cannot propagate faster than light in the standard model, and it can be regarded as the quantum field theory equivalent of the infinite energy argument.

me: The SR part of Quantum field theory means that measurements are once again adjusted to try to set lightspeed as constant.

However, there is no completely rigorous proof of anything in the quantum field theory of the Standard Model, since no one has yet succeeded in showing that the theory is completely self consistent; and in fact, most likely it is not!

me: Wow, admitting that quantum field theory might not be consistent.

In any case, there is no guarantee that there are not other undiscovered particles and forces that disobey the no-FTL rule.

me: There is no “no-FTL rule”; it’s just a bodge by people confused by Einstein stuff.

Nor is there any generalisation that takes gravity and general relativity into account. Many physicists working on quantum gravity doubt that such simplistic expressions of causality and locality will be generalised. All told, there is no guarantee that light speed will be meaningful as a speed limit in a more complete theory that might arise in the future.

18. Grandfather Paradox

A better argument against FTL travel is the Grandfather Paradox. In special relativity, a particle moving FTL in one frame of reference will be travelling back in time in another.

me: What we have here is what was FTL in Newtonian physics transformed away to become SR (that would be type 1 FTL) and then if SR was claiming there is still an FTL effect (that would be type 2 FTL). And the type 2 FTL would be causality violation.

FTL travel or communication should therefore also give the possibility of travelling back in time or sending messages into the past. If such time travel is possible, you would be able to go back in time and change the course of history by killing your own grandfather. This *is* a very strong argument against FTL travel, but it leaves open the perhaps-unlikely possibility that we may be able to make limited journeys at FTL speed that did not allow us to come back. Or it may be that time travel is possible and causality breaks down in some consistent fashion when FTL travel is achieved. That is not very likely either, but if we are discussing FTL then we had better keep an open mind.

Conversely, if we could travel back in time we might also claim the ability to travel FTL, because we can go back in time and then travel at a slow speed to arrive somewhere before light got there by the usual route. See the FAQ article on Time Travel for more on this subject.

me: The mess that Einstein left us leads to that further mess.

Open Possibilities for FTL Travel

In this last section I give a few of the speculative but serious suggestions for possible faster-than-light travel. These are not the kinds of thing usually included in the FAQ because they raise more questions than answers. They are included merely to make the point that serious research is being done in this direction. Only a brief introduction to each topic is given; more information can be found all over the Internet (and should, like almost everything on the Internet, be taken with a huge grain of salt!).

me: Next section was tachyons, but I dealt with tachyons earlier.

20. Worm Holes

A famous proposition for global FTL travel is to use "worm holes". Worm holes are shortcuts through space-time from one place in the universe to another which would permit you to go from one end to the other in a shorter time than it would take light passing by the usual route. Worm holes are a feature of classical general relativity, but to create them you have to change the topology of space-time. That might be possible within a theory of quantum gravity.

me: All just stuff that GR gives us. Just a way of talking about things. It's better to talk about things from a Newtonian physics perspective.

To keep a worm hole open, regions of negative energy would be needed. Misner and Thorne have suggested using the Casimir Effect on a grand scale to generate the negative energy, while Visser has proposed a solution involving cosmic strings. These are very speculative ideas which may simply not be possible. Exotic matter with negative energy may not exist in the form required.

Thorne has found that if worm holes can be created, then they can be used to construct closed timelike loops in space-time which would imply the possibility of time travel. It has been suggested that the "multiverse" interpretation of quantum mechanics (many universes co-existing) gets you out of trouble by allowing time to evolve differently if you succeed in going back to a previous time. But multiverses are entirely out of keeping with the Ockham's Razor approach to doing science, and constitute more of a popular interpretation of quantum mechanics than a serious physical theory. Hawking says that worm holes would simply be unstable and therefore unusable. The subject remains a fertile area for thought experiments that help clarify what is and what is not possible according to known and suggested laws of physics. [5]

me: All just building more mess upon the mess that Einstein left us in.

21. Warp Drives

A "warp drive" such as used in the Star Trek science fiction series would be a mechanism for warping space-time in such a way that an object could move faster than light. Miguel Alcubierre made himself famous by working out a space-time geometry which describes such a warp drive. The warp in space-time makes it possible for an object to go FTL while remaining on a timelike curve. The main catch is the same one that may stop us making large worm holes. To make such a warp, you would need exotic matter with negative energy density. Even if such exotic matter can exist, it is not clear how it could be deployed to make the warp drive work. [6]

me: More mess. From GR way of looking at things – we have gravity as spacetime distortion. In Newtonian physics we stick to Euclidean geometry and have forces. It's easier to stay with Newtonian physics.

Conclusion

- To begin with, it is rather difficult to define exactly what is really meant by FTL travel and FTL communication.

me: Yes because of the mess Einstein left us, and the continuation of working within the context of that mess to add more mess.

Many things such as shadows can go FTL, but not in a useful way that can carry information.

me: No in Newtonian physics context FTL and information transfer at FTL is possible. If we transform this type of FTL away and alter things to fit Einstein's relativity which wants to limit things by c , and we still have FTL in that context of Einstein's relativity then we have to make a mess about no longer being able to understand concepts like "information" and we need to mess them up to mean something else.

- There are several serious possibilities for real FTL which have been proposed in the scientific literature, but these always come with technical difficulties.

me: Not "always". Author gave an example above, just author wanted more evidence.

- The Heisenberg Uncertainty Principle tends to stop the use of apparent FTL quantum effects for sending information or matter.

me: It does not; that's now just a misunderstanding of Heisenberg's uncertainty principle. In Quantum mechanics we have uncertainty interpreted as acting on particles, for instance – uncertainty on electrons but we are still able to transmit information with electrons; that was for sublight speeds, there is no difference for FTL.

- In general relativity there are potential means of FTL travel, but they may be impossible to make work. It is thought highly unlikely that engineers will be building space ships with FTL drives in the foreseeable future, if ever, but it is curious that theoretical physics as we presently understand it seems to leave the door open to the possibility.

me: Says “unlikely” but still considers it a “possibility”, author just does not know. By my articles – what GR represents can be represented in Newtonian physics context, and Newtonian physics allows FTL.

- FTL travel of the sort science fiction writers would like is almost certainly impossible. For physicists the interesting question is "why is it impossible and what can we learn from that?"

me: I dealt with this- Einstein left us a mess; and that’s what we learn from this. There is no need for that mess by simple return to Newtonian physics.

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my comments c.RJAnderton2011-02-09