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What Physical Process Regulates the Constant Speed of Light?

Thierry De Mees
Independent researcher
thierrydemees @ telenet.be

In this stroll about light in the context of the nowadays state of science, I analyze Einstein's postulate of the constancy of the speed of light. In a former paper, it is found that the Special Relativity Theory is consisting of two independent concepts, which were put in the right context of physics. It results in the physical limitation of the theory's validity to local events, under conditions. Also the question whether light is made of particles or waves is solved, and it results in unveiling the physical process that limits and locally standardizes the speed of light.

Keywords: Special relativity theory, light, electromagnetism, field, speed of light, inertial reference frame, aether, ether, gravity, gravity field, particle-wave duality

1. Introduction

In a former paper [7], I have analyzed the two postulates of the special relativity theory in a physical context. Here, the essential results are shown, and the consequences for a real, physical environment in which light can propagate at a constant speed are analyzed. Therefore, the true nature of light, either in the form of particle or as a wave, or as both, has to be clarified.

2. Essentials of the special relativity theory

2.1. Einstein's thought experiment with light.

Einstein performed a thought experiment [1], in which he defined inertial reference frames, say, frames at a constant velocity (inertial reference frames), and used light signals to communicate between them.

He wanted to look at one frame as seen from another frame, and to discover what the other frame would look like when receiving the signals: what would length look like and what would the time pulses look like, by using a light signal between the frames? The relationship is expressed by the deformation of the light signals, which can be written down mathematically as transformation rules.

The result was that if an inertial reference frame was moving, the lengths, as seen from the other frame, would be shorter than its proper lengths. If both frames were carrying a ruler, the ruler of the moving frame would be seen as being shorter by the exchanged light communication signals.

2.2. Relativity *of*, or *between* inertial reference frames?

There is however also the principle of relativity of the inertial reference frames, which Einstein found a reasonable concept by comparing a man in a train, who was suddenly seeing the window of the train next to his window moving. Was it his train or the other train that moved?

However, due to this relativity principle, every inertial reference frame can pretend that it is standing still and that the other inertial reference frame is moving [3].

The conclusion is that in that case, every set of two inertial reference frames will see, in each of the frames, that the signals are transformed the same way by the transformation rules.

Hence, it is not possible that the light signals would physically affect any property of the objects within the inertial reference frames, because then, all the inertial reference frames would be deformed the same way, as seen by any other inertial reference frame. The so-called FitzGerald-Lorentz contraction, which claim the real contraction of the rulers instead of the apparent contraction as seen from another inertial reference frame is therefore invalidated in the context of the special relativity theory [3].

Indeed, it is just about the deformation of light signals between frames, and effectively, the signals will always be as the transformation rules prescribe.

2.3. The constancy of light and its consequences in the Special Relativity Theory.

In the transformation rules of the light signals between the inertial reference frames, not only the length of rulers was calculated, but also the changes of the time pulses between them.

It was also possible, when assuming that inertial masses and intrinsic energy were interchangeable by the simple equation $E = mc^2$, and when assuming that the speed of light is a constant for each inertial reference frame, whether moving or not, to define an expression for masses in terms of length and time values, to combine it with energies, both kinetic and intrinsic, and finally, with masses.

Due to the law of energy conservation, Einstein could then associate mass, time and length as mutual variables, by definition. By that, he made length and time suddenly variable by definition, during his calculus, without even having verified this by observation or experiment. The old concept since millions of years that time is intrinsically invariable, and can only be perceived as different due to an altered perception, was allegedly trashed by the idea that the speed of light would be identical at any place in the universe, whatever the speed of any of the inertial frames would be.

In this paper, I will describe the physical consequences of this postulate.

3. Postulate of a constant velocity of light : a physical analysis

3.1. Within which boundaries is the speed of light constant?

Einstein referred to Galileo's principle of relativity when he defined the setup of his theory.

Galileo Galilei gave the example of the hold of a ship, in which, for whatever the speed of the ship is, the flies will fly the same and the stones fall the same way with respect to the walls. So, it is impossible to know the speed of the ship when one is inside it, and when no information is given from the outside.

However, by this example, Galileo forgot about the ship at, say, 100 kilometers of distance. If one connects both ships with a bellow, at every place, it 'appears' that the flies fly the same way and that falling stones don't move with respect to the walls. But seen from either ship, the flies move differently with respect to the ships, at every place in the bellow.

The postulate of the constancy of the velocity of light at all places for all the inertial reference frames should be analyzed in more detail, based upon a similar example.

When the local speed of light has been measured as "c" on a planet X in a galaxy A, it is very well possible that the local speed of light is also measured as "c" on another planet Y in a galaxy B, which is moving with a speed v towards (or away from) the planet X.

3.2. A physical, velocity-regulating process for light?

It means that there must exist a transition of the measured speed of light from the planet X to the planet Y, depending from where (the planet X or Y, or in-between) the measurement is made. Here, I consider 'measuring' as something virtual, as if we had an measurement tool at infinite speed, resulting in instantaneous information over the universe. It will not harm the general reasoning, because the same reasoning occurs with Galileo's ships, or with waves at the surface of water at different places. The supposition that the speed of light is the ultimate velocity in our world isn't relevant here.

When analyzing the transition of the speed of light between the planet X in galaxy A and the planet Y in the galaxy B, both measuring the value 'c' locally, but not globally, a suitable physical explanation is then that the speed of light can be bound to each mass in the galaxy, which is not forbidden from the results of Michelson's and Morley's experiment, as we will see in the next section. Practically, one can suggest that the light beam is bound to every local gravitational potential.

Locally, it will be very difficult to measure the velocity of a light beam at the moment of emission from a device that moves at a velocity v with respect to the Earth's surface. Likely, the light beam's velocity will already been adapted to the Earth's conditions, and show the velocity as being "c" at the moment that it leaves the atoms of the crystal. These atoms, made of electromagnetic components, can also behave under the Earths' magnetic field, and only an electromagnetic analysis would be useful to predict some outcomes, such as the ones that are found in a next section.

3.3. For which situation is the Galilean relativity valid as applied in the special relativity theory?

Is the concept of such a constant velocity valid in the frame of the special relativity theory? The postulate means that even when two or more inertial reference frames cross at the same place at different velocities, allegedly all the inertial reference frames would measure a very single light beam, emitted from any other inertial reference frame as having the same velocity c. This is impossible at one single place because in that case, the physical velocity of that light beam is undefined.

Hence, physically, the speed of light cannot be related to the inertial reference frames, but must be related to another substance.

4. The propagation of light: is light a wave or a particle?

4.1. Issues with light as particles.

It is commonly believed that light is consisting of particles, named photons, or at least a duality wave-particle.

This is fed by the idea that energy and momentum are easily transported within a particle, and that there is allegedly no medium in which light, as a wave, needs to be transported, as deduced by the nowadays' interpretation of the Michelson and Morley experiment. However, as we will show in the next section, this interpretation has important issues.

There is a problem by the concept of light as particles: when light is emitted from a distant galaxy, it would acquire the speed of that galaxy with respect to us. Hence, all the light coming from other galaxies would get different speeds when hitting our detection systems.

What physical process would then be able to regulate the speed of light on Earth in that case? If such a velocity regulation would be physically possible with particles, wouldn't the speed be reduced? In the case of light, its mass is no rest mass, but it has a momentum, so one could associate a kinematic mass and a velocity to it. But what does a kinematic mass with zero rest mass physically mean?

On the other hand, it can be proven [9] that the gravitational acceleration (free fall) allows to Planck-scale particles to get the speed of light. For larger particles than the Planck scale, the maximal speed of free fall is lower. In the case of light, their properties are much higher than the Planck-scale, and the free fall can-

not account for the regulation of speed of light. So, neither in a gravity field, nor in a medium such as an aether, light as particles with a fixed speed can exist.

In order to further investigate light in terms of particles or waves, we first need to investigate the logical validity of the dismissal of an aether as the carrying medium for light, as claimed nowadays by scientists, which based their ideas upon the Michelson and Morley experiment.

4.2. Michelson & Morley: what did they prove?

What did Michelson and Morley try to prove? They tested the following hypothesis: assuming that light is carried by an aether, assuming that this aether is global, and assuming that the Earth is moving with respect to this aether, what is its direction and velocity?

The experiment was negative, which confirms that the hypothesis was false.

Since the hypothesis consisted of a multiple set of assumptions, only one of the assumptions must be false: either assuming that light is carried by an aether, or that this aether is global, or that the Earth is moving with respect to this aether, is false.
Indeed, in logic, if the statement is "A *and* B *and* C", the negation is "not A *or* not B *or* not C".

Hence, several possibilities remain open with respect to the existence of an aether, and the non-existence of aether is surely not proven.

In the case that an aether of propagation exists, it is consistent with Michelson and Morley experiment that this medium would likely be connected to the gravity field itself, which on Earth would result in a null measurement of that experiment.

4.3. Since the aether is not excluded, and since light are no particles, what about light as waves?

The impossibility to see light as 'just' particles, leaves us with the alternative that light can be solely waves.

This is the very meaning of the mathematical electromagnetic formulation of light, in which both the electric and the magnetic field play a role. It is known that waves can transport and do transport momentum and energy. It is also known that waves can only occur by the grace of a medium that, as generally observed in all the scientific domains (water, air, a rope,…), consists of much smaller particles than the waves themselves.

Due to the motion of the initial impulsion given at the medium, the momentum and energy are transported further, with a velocity that is characteristically defined by the very physical properties of the medium.

In general, the velocity of waves in a medium is defined by $v = \sqrt{\mathscr{E} / \rho}$, in which $\mathscr{E}$ is the energy density (tension) and ρ is the mass density of the medium, not of the wave itself.

Remark that this equation can be written for light as $c = \sqrt{\mathscr{E} / \rho} = \sqrt{E / m}$, and that this corresponds to the connection of mass with energy, this time however interpreted in the sense that Louis de Broglie meant it: particles as self-trapped electromagnetic waves in a confined space. Hence, it is rather so that waves and particles are both waves, but that because of the confinement of the waves in particles, one gets another entity: the particle itself can behave as a separate unit, with its own velocity, momentum and energy, independent from the characteristics of the confined wave. However, the confined wave will have a rest mass, which suggests that the confined wave would have obtained a mass that differs from zero, solely by the confinement itself. This may have some consequences for the understanding of matter that can be analyzed in future papers.

4.4. Can a wave exist without a propagating medium?

The question whether a wave can exist without a propagating medium seems to be questioned in nowadays' science. However, there does not exist any scientific example in which waves would be propagating without such a medium: neither in liquids, in solid materials, in gases, nor in a rope, waves can propagate without the medium itself. The transportation of momentum and energy of a wave occurs solely by the local alteration (compression-depression) of the medium [8].

The very definition of the propagation velocity is always depending from the physical properties of the medium. For light, the electromagnetic properties in 'vacuum' are ε_0 and μ_0, and in other materials, the propagation velocity of electromagnetic waves is given by ε and μ. The latter values are to be seen as modifications of the values in 'vacuum', due to the structure of the atoms in the materials. The values ε and μ should not be seen as pure values of the matter and produced by the materials themselves.

Hence, the values ε_0 and μ_0 are intrinsic values of undisturbed fundamental medium of the aether. All the matter, as seen by Louis de Broglie are waves within the same medium, and they disturb the values by the presence of the atomic structure.

5. Conclusion

In this paper, it has been explained that Einstein's thought experiment with light *between* inertial reference frames resulted in the *apparent* variable length, not a real length change of rulers as the Fitzgerald-Lorentz length contraction prescribes, when seen by other inertial reference frames. Due to the alleged constancy of the speed of light in all situations in the universe, mass and time became variable as well, allegedly intrinsically.

However, it was shown that Galileo's relativity principle, on which Einstein's second postulate is based (constancy of the speed of light), is only valid locally, not globally. The example given show that the net speed of light, at any place between mutually moving galaxies, when "seen" from either galaxy, will differ from the speed of light. That is even so if locally, a speed of light is measured. The example with the bellow between two ships within Galileo's concept shows this extensively.

Further, it has been shown that light as particles would result in an infinite number of light speeds of light from distant galaxies hitting the Earth, because the light particles would then get the speed of the emitting galaxies. A regulating physical process for these particles' speed is inexistent, and would never result in

a fixed speed on Earth. One exception has been given by the free fall, for which the value of maximal speed is given by the size of the falling objects. In the case of a value of the order of the speed of light, Planck-sized particles are required, which don't correspond with the expected concept of light as particles.

Furthermore, it was shown that by the application of mathematical rules of logic, Michelson's and Morley's experiment don't exclude aether at all, and that the option that light is purely made of waves allows to define a regulating physical process in the form of a medium of propagation. Such a medium is seen in any wave process, and the propagation speed of the wave is defined by the medium's properties, not by the properties of the wave itself. The medium would then likely be connected to the gravity field, which on Earth would result in a null measurement.

Then, it has been shown that waves can only exist by the grace of a medium, as it is always observed in Nature. In the case of light, the electromagnetic properties ε_0 and μ_0 of the medium in 'vacuum' are defining the speed of light. In other materials, the atomic structure *alters* these values, but is not 'creating' the electromagnetic values ε and μ.

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