Is the light velocity constant?

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Abstract – The pretension in this paper is to question the constancy of light velocity.

Keywords – light velocity, principle of constancy of light velocity, Special Relativity Theory, Michelson, one-way, average, mean, range of light velocities, Venus, radar, Earth's movement.

§ 1

The pretension in this paper is to question the constancy of light velocity (*c*).

I would like to at the moment be able to answer whether yes or not for this question, but it is not possible yet for me. According to which I will explain in this article, I am inclined to reply that the speed of light is not constant in the sense given by the Theory of Special Relativity. On the other hand, according to the General Relativity, the speed of light varies with the gravitational potential, and this is of course acceptable to me. It is also true that the speed of light varies with the medium, e.g., air, water, glass, etc., but here only analyze the speed of light (hypothetically in vacuum) relative to a moving reference frame. The answer to this question is a necessary condition for being able to build a consistent Lorentz transformation, or a new transformation of time and space.

Voigt[1], Larmor[2], Lorentz[3] and Poincaré[4] (Poincaré gently correcting Lorentz), as well Einstein[5], built transformations of space and time that are compatible with the constancy of the speed of light, but there was insufficient experimental precision at that time (the late nineteenth century to the early twentieth century) to support this hypothesis.

Following [6], the oldest *c* measures are as following in Table 1:

Year	Scientist	Value
1638	Galileo	at least 10 times faster than sound
1675	Ole Roemer	200,000 km/s
1728	James Bradley	301,000 km/s
1849	Hippolyte Louis Fizeau	313,300 km/s
1862	Leon Foucault	299,796 km/s

Table 1 – The first measures of the light velocity

At the present the speed of light is accepted as constant equal to (in the vacuum)

$$c = 299{,}792{,}458 \; m/s,$$

value adopted at the Generia Conference of Weights and Measures, 1983 October 21.

Others experimental values in [6] are

U.S. National Bureau of Standards: 299 792 457.4 ± 1.1 m/s
The British National Physical Laboratory: 299 792 459.0 ± 0.8 m/s

Aparently the standard value adopted is the arithmetic average of the two values above, truncated for integer number and no errors.

Question 1: Can 3.5 m/s in Physics be considered a negligible value, ignored without further complications? And, if yes, is true that 1.1 = 0.8 = 0.0 in some measure in Physics, no problems, all right?

§ 2

Important paper on the determination of the light velocity is given in [7], by the famous Albert A. Michelson, published in 1880, contemporary to Voigt, Lorentz and others involved in the Theory of Relativity.

The result of Michelson was initially (May, 1878) an average of 186,500 $\pm$ 300 miles per second, or 300,140 kilometers per second. Your 10 values ranged from 184,500 to 188,820 miles per second, a difference equal to 4,320 miles per second, or 4,320 $\times$ 1,609.344 $\cong$ 6.95 $\times$ 10^6 m/s, a big difference, 2.3% light velocity. This difference is much larger than the Earth's rotation speed, about 1,675 km/h or 465 m/s, depending on the latitude place, and that is also greater than the velocity of the Earth translation, about 29.78 km/s $\cong$ 3.0 $\times$ 10^4 m/s, depending on the date of year.

More elaborate experiments resulted in the average value of

$$c = 299\,852 \pm 60\ km/s$$

with the velocities varying from 299,650 km/s to 300,070 km/s, interval size equal to 420 km/s or 4.2 $\times$ 10^5 m/s, 903 times greater than Earth rotation velocity, 14 times greater than Earth translation velocity.

The final result given by Michelson was, in km/s (note that Einstein also used the symbol V to indicate the speed of light),

The mean value of V from the table is	299 852
Correction for temperature	+12
Velocity of light in air	299 864
Correction for vacuo	+80
Velocity of light in vacuo	299 944 $\pm$ 51

Michelson concludes that "the final value of the velocity of light from these experiments is then 299940 kilometers per second, or 186380 miles per second".

See that Michelson assigns a correction speed for the temperature (12 km/s = 1.2 $\times$ 10^4 m/s), a correction velocity for the vacuum (80 km/s = 8.0 $\times$ 10^4 m/s), and for this reason the measurement of light velocity in the vacuum was indirect.

Question 2: Can a relativistic theoretical physicist be at peace when he knows that a speed that is considered constant may vary up to 420 km/s in experimental measurements?

§ 3

The last Michelson's work on light velocity is given by [8], published in 1935, after your death (1931). There were made 2885.5 determinations of the light velocity, the simple mean value of which was 299,774 km/s, with an average deviation of 11 km/s from the mean. The measurements of the velocity of light were made at the Irvine Ranch near Santa Ana, California, during the period September, 1929, to March, 1933.

The last Michelson's paper is very suitable to make an analysis of values that he himself has not obtained.

The range of velocities is from 299,726 km/s to 299,825 km/s, a length equal to 99 km/s = 9.9×10^4 m/s, or about 213 times the velocity of Earth's rotation, about 3.3 times the velocity of Earth's translation.

Question 3: Well, the planet Earth is not at rest, that we know (rotation, translation and others complex movements). Why a difference in speeds of the order 3-213 times the speed of Earth's movements can be considered negligible, equal to zero, in order to be considered that the speed of light is really a single constant?

§ 4

There are an important paper write in 1969 by Dr. Bryan G. Wallace, *Radar Testing of the Relative Velocity of Light in Space*[9], whose *Abstract* is very clear: Published interplanetary radar data presents evidence that the relative velocity of light in space is $c + v$ and not c.

In the last paragraph Wallace concluded: Although analysis to date presents strong evidence against c and for $c + v$, I don't think it can be considered reasonably conclusive until a full $c + v$ investigation is made.

He analyzed in his paper on the 1961 Venus Radar data presenting evidence that the velocity of light in space is consistent with $c + v$ Newtonian particle model. A major study of this question, made by the same author, may be encountered in [10].

§ 5

According to Assis[11], to prove that the speed of light does not depend on the observer's movement would have to be necessary to make laboratory experiments in which the detector is moving at high speeds (near *c*) relative to the Earth and the light source (supposedly at rest in Earth). We do not have know which there is experiences that have confirmed the conclusion of Einstein (the principle of the constancy of the speed of light).

Wesley[12], Tolchelnikova-Murri[13], Hayden[14], Monti[15] and many others had strong and convincing arguments that the methods used by Roemer[16] and Bradley[17],[18] for obtained the value of the speed of light proves that the measured value of this speed depends on the observer's velocity relative to the source.

Another (but not unique) important reference for the study of the constancy of the speed of light is "*Special Relativity and Its Experimental Foundations*"[19]. In this book there are many analyses of various experiments and specially concludes that the constancy of the speed of light is unproven in motions from one-way. In my understanding, the speed of light measures utilize mostly multiple paths for the movement of light, and on average the value of its speed can appear to be "approximately" constant ($\bar{c} \cong c$). For example, with two measures in opposite way,

$$\overline{c} = \frac{c_+ + c_-}{2} = \frac{(c+v)+(c-v)}{2} = c,$$

where $c_+ = c + v$ is the light velocity measured in a way (in relation to the laboratory considered in an inertial reference frame), $c_- = c - v$ is the light velocity measured in the opposite way (also in relation to the same laboratory in the same referential, but eventually done in other day or in other time, i.e., in other astronomical position) and $\overline{c}$ is the correspondent mean value of the light velocity calculated on this paths. Obviously, in the previous example it was used only two speeds, however a generic number n of measures c_i for light velocities can be made and will be such that

$$\overline{c} = \frac{\sum_{i=1}^{n} c_i}{n} \cong c,$$

supposing that the number of velocities in a way and in an opposite way is approximately the same number, no excess of $+v$, no excess of $-v$ (to be more exact, the value of these speeds v will also can vary, and evidently here do not intend to make a thorough study of this subject).

Zhang says: *The key point in Einstein's theory is the postulate concerning the constancy of the (one-way) velocity of light, which contradicts the classical (nonrelativistic) addition law of velocities. This postulate is needed only for constructing well-defined inertial frames of reference, in other words, only for synchronizing clocks (i.e., defining simultaneity). It is not possible to test the one-way velocity of light because another independent method of clock synchronization has not yet been found.*

Which are the transformations of time and space that would replace the Lorentz transformations if they are valid the speed of light $c_- = c - v$ and $c_+ = c + v$ to observer (or detector) moving with speeds $+v$ and $-v$, respectively, in relation to a referential considered fixed, with light moving with velocity *c* in the positive direction of this referential?

Assuming linear and symmetrical transformations, the valid transformations are Galilean transformations,

$$t' = t$$
$$x' = x - vt$$
$$y' = y$$
$$z' = z$$

that brings the disadvantage of not making covariants the Maxwell equations and nor the equation of electromagnetic waves, but also gives us the possibility to build new theories, more logically consistent, without contradictions of the Theory of Relativity.

We concluded that we cannot be sure that the speed of light is constant, in the meaning adopted by the principle of constancy of the speed of light in the Special Relativity. Voigt, Larmor, Lorentz, Poincaré, Einstein, each one in his own way found transformations of time and space that make the speed of light independent of the speed of source and the reference system (supposed constant speeds), but there are experimental evidences that would suggest that the speed of light is not constant, as indicated by Bryan G. Wallace, Assis and others. The analysis of the Michelson data for obtaining the speed of light also shows a surprisingly wide range of experimental values were obtained for this speed, and has nothing in common with the constant speed of light rigidly adopted currently as the single pattern value.

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