On the Physical Consistency of the Special Theory of Relativity (STR)

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Abstract

There are well-established facts whose validity is beyond any doubt, such as the fact that 2 + 2 = 4 or the fact that, say, a lamp that can only flash once in its entire lifetime can only flash at a given coordinate x and at a given time t in a given system O. Such lamp cannot flash at a given moment t at two different coordinates x in this system O. A theory is physically inconsistent if it leads to conclusions which contradict such well-established facts. In this text arguments are given which show that STR leads to conclusions which are in contradiction with well-established facts and therefore it is physically inconsistent.

To analyze the physical consistency of the Special Theory of Relativity (STR) one does not need to go very far. One only needs to pay attention to the fact that in the moving system O' the coordinates of an event, say, flashing of light (of a lamp that can flash only once in its entire lifetime), are fixed – flashing of said lamp in any stationary system only occurs at a given point and at a given time. System O' (which for an observer in O' is a stationary system) is no exception in this respect – flashing of light in O' only occurs at a given point x' and at a given time t'.

Especially notice that the time t' of the event, say, flashing of light, in O' is fixed, i.e. $t' = \text{const}$.

Experience shows that the importance of the above statement (which , actually, is an application of the first postulate in STR called the "Principle of Relativity") is usually underestimated. Therefore, we will express it again in the following way – an event that occurs in O at a given concrete x and at a given concrete t occurs in O' at a given concrete x' and at a given concrete t'.

Note that the above statement has nothing to do with Lorentz transformations or with the state of motion of either system.

Thus, any theory that would derive formulae to express the time t' of the occurrence of an event in O' as a function of parameters such as coordinates, velocities etc. of another system, say O, when that event has occurred at a given concrete x and at a given concrete t in O must arrive at the conclusion that $t' = \text{const}$, otherwise such theory will be physically inconsistent.

Let us see whether the time t', derived by STR through the application of the Lorentz transformations derived therein, is indeed constant. According to the Lorentz transformations which, as just mentioned, STR is based on [1], the value of t' is given by the following expression

$$t' = \beta\left(t - \frac{vx}{c^2}\right)$$

where $\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$, t and x are respectively the time and the space coordinate of the event (say, flashing of light) in the stationary system O, v is the velocity of the moving system O' versus the stationary system O and c is the speed of light.

Let us expand coefficient β and, for simplicity, retain only first two terms. We obtain:

$$\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \approx 1 + \frac{1}{2}\frac{v^2}{c^2}$$

Last expression may be substituted in the above expression for t':

$$t' = \left(1 + \frac{1}{2}\frac{v^2}{c^2}\right)\left(t - \frac{vx}{c^2}\right)$$

and after rearranging one obtains:

$$t' = t + \frac{1}{2}\frac{v^2 t}{c^2} - \frac{vx}{c^2} - \frac{1}{2}\frac{v^3 x}{c^4} \qquad (1)$$

It is obvious from the above expression, i.e. the expression which STR derives for the coordinate t' in O', that the coordinate t' in O' is not a constant even if the event has occurred in O at a given concrete x and at a given concrete t but depends on the velocity v. In other words, according to STR $t' \neq \mathrm{const}$. This conclusion following from STR, namely that $t' \neq \mathrm{const}$, is in contradiction with the obvious physical requirement that for the described circumstances (event occurring at the given concrete x and at the given concrete t in O) t' (as well as x') must be a constant, i.e. under the circumstances physically it is mandatory that $t' = \mathrm{const}$.

In view of the importance of this observation it deserves some more comment. Notice that t' is the local time in the system O', i.e. t' is the time which an observer sitting in O' will measure. An observer sitting in O' will always measure the local time in O' independent of what the velocity v of O' is with regard to O. In other words, an observer in O' looking at his watch will always see the time running the same way both when O' is moving at a speed close to the speed of light versus O and when O' is moving at speed zero versus O. This is the truth about what happens with time in the system O'. As we saw above, the observer in O using STR, however, sees the passing of time in O' differently. And even more, the observer in O claims that what he concludes about the passage of time in O' is the truth about how time runs in O' and not that it is just how it appears to him to be running. In other words, the observer in O claims that conclusions about time which STR gives are not similar to the conclusions one draws when seeing ships in the horizon – the ships appear small but one knows that thit is due to the perspective; in reality, the ships are quite big; one would never seriously claim that the ships are actually as small as those specks that appear in the horizon.

One may argue that the velocity v is not just any velocity but is a quantity whose value is determined by the concrete values of the mentioned x and t, i.e. $v = \frac{x}{t} = \mathrm{const}$ and in this way, apparently, the requirement $t' = \mathrm{const}$ is fulfilled.

If, however, the velocity v in the above expression for t' is indeed $v = \frac{x}{t} = \mathrm{const}$ then we may write the above expression for t' (neglecting the terms of higher than second order in $\frac{x}{c}$) as:

$$t' = t - \frac{1}{2}\frac{x^2}{c^2}\frac{1}{t} \qquad (2)$$

It is seen that at small values of x and large values of t the second term on the right-hand side of eq.(2) can be neglected. However, this leads to

$$t' = t$$

which is common sense, it indicates that time is absolute and is contrary to the widely celebrated notion, claimed by STR, of the “relativity of time”.

If one is reluctant to neglect the second term on the right-hand side of eq.(2) and decides to have it retained, then, for a given t in O the value of the time t' in O' will depend on the second power of the position x in O. In such a case the position x of the event in O should be, according to STR, as follows:

$$x = \pm A \qquad (3)$$

where $A = \sqrt{2c^2\left(t^2 - tt'\right)} = \mathrm{const}$. Equation (3) obtained according to STR maintains that the event of flashing of light in O at one and the same time t in O, has occurred at two different positions, namely at position $x = +$ À and at position $x = -$ À.

However, we know with full certainty that the flashing of light had occurred at time t in O only at one position, namely, only at position x. The evident physical circumstance, namely that the flashing of light has occurred at time t in O at only one position x indicates that the STR makes a non-physical prediction for the place the flashing of light should occur – incorrectly claiming that flashing of light should have occurred at two different positions at once.

One may decide to argue that the velocity v in eq.(1) is not connected with the concrete values of x and t at which the event in O occurred, and may be a value different from the mentioned concrete value $v = \frac{x}{t} = \text{const}$. If this were the case, however, then, according to STR, at the given x in O the event would have occurred at a different unprimed time, say t_1 in O and not at the already mentioned concrete time t in O. This would mean that an event that can only happen once (say, a lamp that can only flash once in O in its entire lifetime), namely at time t in O, STR says should flash again at another time t_1 in O. As is quite obvious, because of the said construction of the lamp, such double flashing of the lamp is physically impossible which requires the observation that the conclusion following from STR that there should be a second time t_1 in O of the lamp flashing is physically untenable.

STR also cannot be saved if one now resorts to neglecting of terms multiplied by the second and higher powers of $\frac{v}{c}$, as it is done on p. 54 of [1]. Neglecting of terms multiplied by the second and higher powers of $\frac{v}{c}$ in the above expression (1) leads to the following equality:

$$t' = t$$

which, as already noted, is common sense, it indicates that time is absolute and is contrary to the widely celebrated notion, claimed by STR, of the "relativity of time".

Reference

1. A.Einstein, "The Principle of Relativity", Dover, 1952.