SPECIAL RELATIVITY´S HEEL OF ACHILLES: THE UNITS OF MEASUREMENTS

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ABSTRACT

Max Born´s opinion - that "special" relativity theory (SRT) were anchored in experiment - notwithstanding, the importance of measurement units has been repeatedly pointed out. The quotations listed below shed light on the origin of contradictory interpretations of SRT and provide the ground for rejecting it as irrelevant for physics.

KEY WORDS: Special relativity; units of measurement; velocity of light

INTRODUCTION

The "special" theory of relativity, a confused and self-contradictory version of Lorentz and Poincaré´s theory of electrons, opened the door for the reckless mathematization of "modern" physics, till to the present discredited situation of fundamental physics.
SRT has been built upon two postulates:

> (a) the purely *mathematical* requirement of *covariance* of the equations embodying the laws of physics and
> (b) the unintelligible independence of the velocity of light propagation from the velocity of the observer/detector.

Although explicitely pointed out before 65 years by the (latter) "doyen of British relativists" McCrea, that ***postulate (b) could be implemented only by an "adjustment of measurement units",*** this outmost important remark has been swept under the rug and never found his place in the presentations of SRT.

The equivocal formulation of the theory allowed the formulation of both *passive* and *active* interpretations of the Lorentz transformations (LT). Einstein´s own understanding (followed by the overwhelming majority of present day physicists) which he hold till his last day, was a *mixture* of the two interpretations. Due to a clever implementation of the "Heads I win, tails you lose" (Hazelett) tactic, the ongoing commuting between the two pseudophysical interpretations with one mathematical expression (the LT) made possible the survival of SRT hundred of textbooks and monographies devoted to an understandable presentation during almost a century.

Bergson, Cullwick and Sachs have been prominent advocates of the passive interpretation of SRT, according to which "length contraction" and "time dilation" are non-physical, reciprocal, perspective effects (actually pseudo-effects), while

the majority subscribes more or less silently to the neo-Lorentzian, active interpretation, which takes "rod contraction" and "slowing-down of clocks" as physical, non-reciprocal, absolute affects induced by the absolute motion w.r.t. a unique, fundamental frame of reference.

The experimentally secured *mass increase with velocity and the inertia of energy* stay appart from the interpretational mess, being ***dynamical*** physical effects, rather than consequences of ***a false kinematics*** relaying upon Lorentz transformations (LT). In what the following quotations are concerned, I have to confess that for over twenty years I was unaware of the important work of the late Julio Palacios, dealing specifically with SRT and units of measurement. This work I shall discuss in a forthcomming article.

McCrea, W. H. "Relativity Physics" (Methuen, London, 1935) p. 10

"Let the instant when O, O´ coincide be taken as the origin of time t = 0, t´ = 0 for A[observer in (S)] and B[observer in (S´)]. Then suppose that at this instant a flash of light is emitted at O (or O´) and gives rise to a wave front spreading out from O (or O´). Then this wave front is composed of a collection of events observed by A, B. By (ii) it is for A at time t a sphere with centre O and radius ct , where c is the velocity of light in (S). Its equation is therefore:

$$x^2 + y^2 + z^2 - (c.t)^2 = 0 \qquad (1)$$

Now, by a further application of the principle of relativity, the result (ii) must hold also for observer B, and therefore the equation of the wave front in (S´) at time t´ is:

$$x'^2 + y'^2 + z'^2 - (c'.t')^2 = 0 \qquad (2)$$

where c´ is the velocity of light in (S´).

If now (x, y, z, t), (x´, y´, z´, t´) refer to the same event in the wave front, then equation (1) must transform into equation (2) in going from (S) to (S´). But the substitution of a linear transformation in the left-hand side of equation (1) will yield a quadratic in (x´, y´, z´, t´), which must be merely a constant multiple of the left-hand side of (2) if equation (1) is to transform into equation (2). That is:

$$x^2 + y^2 + z^2 - (c.t)^2 = k[x'^2 + y'^2 + z'^2 - (c'.t')^2] \qquad (3)$$

where k is a constant. Further c, c´ can differ only through a difference of units in (S), (S´), for a difference depending on V would contradict the principle of relativity. We may therefore suppose the units so chosen that c = c´, and then a further adjustment of units would make k=1. Then (3) shows that the quantity $x^2 + y^2 + z^2 - (c.t)^2$ is invariant under the transformation sought."

de Bothezat, G. "Back to Newton: A Challenge to Einstein´s Theory of Relativity" (G. E. Stechert & Co., 1936, New York) pp. 130-132

"Let us consider the head of a spherical wave propagating with a velocity c from a center O. In relation to a system of orthogonal axes (S), the head of this spherical wave has for equation:

$$x^2 + y^2 + z^2 - (c.t)^2 = 0 \qquad (1)$$

Suppose now that we want to refer the spherical wave to the system (S´) moving with a velocity V < c and coinciding with (S) at the initial moment. On account of:

$$x = x' + Vt \; ; \; y = y' \; ; \; z = z' \; ; \; t = t' \qquad (2)$$

the head of the spherical wave referred to (S´) will have for equations:

$$(x' + Vt)^2 + y'^2 + z'^2 - (c.t)^2 = 0 \qquad (3)$$

It is possible to bring this equation to a form identical to the previous one by making use of the following *artifice*: Let us use in (S´) instead of the coordinates (x´, y´, z´, t), other coordinates (x´´, y´´, z´´, t´´), related to (x, y, z, t) by the relations (g = Gamma):

$$x'' = g(x - Vt) \; ; \; y'' = y \; ; \; z'' = z \; ; \; t'' = g(t - Vx/c^2) \text{ with } g = (1 - V^2/c^2)^{-0.5} \qquad (4)$$

As already shown, if we substitute (1) (x, y, z, t) by their values in (x´´, y´´, z´´, t´´) taken from the last relations we get:

$$x''^2 + y''^2 + z''^2 - (c.t'')^2 = 0 \qquad (5)$$

That is in the coordinates (x´´, y´´, z´´, t´´) the head of the spherical wave has the same form of equation as in (S). But how are (x´´, y´´, z´´, t´´) related to the coordinates (x´, y´, z´, t) in (S´) ? By substituting in (5) the coordinates (x, y, z, t) by their values (4) we find:

$$x'' = gx' \; ; \; y' = y' \; ; \; z'' = z' ; \; t'' = t.(1/g - gVx'/tc^2) \qquad (6)$$

In order to arrive at the values (x´´, y´´, z´´, t´´) when making measurement in (S´) one will have to proceed as follows: For the measurement of length one will have to use instead of the original unit of length [L] a "special unit" [L´´] related to [L] by the relation:

$$[L''] = [L]/g \qquad (7)$$

When measuring x´ with [L´´] as unit we will get the following numerical value xn´´ of x´:

$$x_n'' = x'/[L''] = gx'/[L] \qquad (8)$$

from which relation it follows that

$$x_n'' \, [L] = gx' = x'' \qquad (9)$$

which means that if we measure x´with [L´´] as unit (instead of [L]) and refer hereafter the numerical value so obtained to the unit [L], x´ will appear as having

the value $x'' = gx'$. In a similar manner, suppose that along the axis $O'X'$ we locate an infinite number of clocks, one at each point, each showing a different time t'' dependent upon ist position x'' and connected to the standard isochronous time t and position x' by the relation:

$$t'' = t(1/g - gVx'/t.c^2) \qquad (10)$$

which is the time required by the relations (6). In order to read upon a clock such a time t'' instead of t , a "special unit" of time $[T'']$ has to be used, related to the standard unit [T] by the relation

$$[T''] = [T]/(1/g - gVx'/t.c^2) \qquad (11)$$

With such unit $[T'']$ of time, we will get for the numerical value of t

$$t_n'' = t/[T''] = (t/[T])(1/g - gVx'/t.c^2) \qquad (12)$$

to which corresponds a time

$$t'' = t_n''[T] = t[1/g - gVx'/t.c^2) = g(t - Vx/c^2) \qquad (13)$$

We are thus brought to the basic conclusion: Let us use in (S´) instead of true lengths and true times, lengths and times the numerical values of which are obtained as follows: We perform our measurements by using instead of standard *units, auxiliary units (7) and (11).* We thus get auxiliary numerical values (xn'', yn'', zn'', tn''); referring these numerical values to the standard units [L] and [T] we get the auxiliary values (x'', y'', z'', t'') which satisfy an equation of the same form as the equation in (x, y, z, t) for the head of the spherical wave considered. *In short we perform measurements in (S´) using deliberately modified scales, but treat the numerical values so obtained as if they were obtained with standard scales..... We are dealing here merely with a mathematical artifice* permittting us to use the same form of an equation under different conditions. The ratio of x'' to t'' is equal to:

$$x''/t'' = gx'/g(t - V.x/c^2) = (x - V.t)/(t - V.x/c^2) \qquad (14)$$

But x as abscissa of the head of the considered wave is equal to ct (x = ct); we thus find:

$$x''/t'' = (ct - Vt)/(t - Vct/c^2) = c \qquad (15)$$

The ratio of x'' to t'' thus turns to be equal to c, but this does not mean at all that the considered wave propagates in (S´) with the velocity c, because x'' and t'' are but auxiliary values and not the true values corresponding to the head of the wave. *Most amazing is thus the fact that after having achieved the correct interpretation of Lorentz´s transformation one can see that this transformation does not involve at all Einstein´s supernatural constancy of the velocity of light propagation because we arrive for the light velocitxy in (S´) at the same numerical value as in (S) only by making deliberately false length and time measurements in (S´)."*

Cullwick, E. G. "Electromagnetism and Relativity: with particular reference

to moving media and electromagnetic induction" (Longmans, Green & Co., London, 1957)

"A common misunderstandingof the Special Theory of Relativity is to suppose that different *units* of space and time must be used *in* the two reference systems, (S) and (S´). The units used by each observer in his measurements are, of course, exactly the same for otherwise the systems could not be reciprocal. It is the space and time *measurements* of a given event, in terms of these units, that in general are different in the two systems, so that the units merely appear to be different, to one observer or the other. In the earlier theory of Lorentz, however, the system was considered to be fixed in the aether, with the system (S´) moving relative to the aether, and the units used in (S´) were supposed to be different from those used in (S). The two systems were not regarded as being reciprocal and the motion of measuring devices of (S´) through the aether was considered to cause actual physical modifications of them. Einstein´s theory of relativity, as previously pointed out, is quite different."

Cullwick´s contention that "the units of measurement in the two systems have to be -of course- equal, otherwise the systems will no more be reciprocal", gives me the opportunity to point out that in the presence of a physical system, all inertial frames of reference (IFR) will be, anyway, not on equal footing; out of all relatively moving IFR´s one and only one will be the "proper" frame of reference. All vector laws of physics will have two qualitatively distinct forms: one, the most simple one, in the "proper" frame of reference and the other, dependent on the uniform relative velocity between the two IFR´s. All physical laws (e.g. the one-over r-square law) have been discovered in the "proper" frame of reference. These laws will retain their form in other IFR´s only if, parallel to the coordinate transformation one *covariantly* transforms the components of vectors, too. Trivially, there has to be reciprocity between two, relatively moving IFR´s, but in the presence of a physical system this reciprocity no more holds. Now, the reciprocity of the relative velocity between two *observer* systems requires identical measurement units, while the *covariance* of the physical laws governing an *observed system* requires a scale change: a true contradiction!

Sachs, M., "On Dingle´s Controversy about the Clock Paradox and the Evolution of Ideas in Science", Int. J. Theor. Physics, Vol. 10, 1974, pp. 321-331

"From my studies of this problem I do not believe that the theory of relativity is logically inconsistent. The reason for Dingle´s conclusion, as I see it, is a false interpretation of the inequality of time scales in relatively moving inertial frames, t =/= t´, that was presented in the early stages of development of this theory. At that time, Einstein identified the abstract time parameter, t, *directly,* with a physical duration of a material mechanism. But the way in which the time dilation arose in the theory of relativity in the first place has nothing to do, directly, with the evolution of a physical mechanism. It rather appeared as an abstract parameter contraction, whose only purpose was to facilitate an objective description of a law of nature, the Maxwell field theory of electromagnetism -the first discovered law exhibiting special relativistic covariance. The solutions of the equations that represent the laws of nature, rather than the independent parameters, such as t , then relate to the predictions of physical effects..... When one measures the difference in the frequencies from identical oscillators that are in relative motion (i.e. the relativistic Doppler effect) it is because ´frequency´ is a number of cycles per ´second´ , and ´second´ is here a frame

dependent quantity in the parametric representation of the measurement. But the ageing, in this case, rather refers to the *number rate* of unstable particle decay, or the measures of separate components of the energy-momentum of a swiftly moving elementary particle. All of these types of observations have well-verified the predictions of special relativity theory. But none of these quantities are physical ageing, *per se.* The different values for these measured quantities in different relatively moving frames of reference are due strictly to the fact that measurements are made from a moving platform, relative to the described matter or radiation -they are not intrinsic physical changes of matter in motion, such as the unwindings of springs or the contraction of rigid rods, as claimed by the majority of physicists today.....I believe that Einstein´s identification of the Lorentz transformation with a physical cause-effect relation, and the subsequent conclusion about asymmetric ageing, was a flaw, not in the theory of relativity itself, as Dingle believes, but rather a flaw in the reasoning that Einstein used in this particular study- leading him to an inconsistency with the meaning of space and time, according to his own theory. If Einstein (and almost the entire physics community) had not been so in error, then I would have to agree with Dingle´s conclusion about the invalidity of the theory; for his criticism -that the logical paradox would be implicit in the theory of special relativity- would then remain unanswered."

Nuthakki, Purna, "The Interpretation of the Theory of Relativity", Int. J. Theor. Phys. Vol. 13, 1975, pp.27-35

"The basis of the quantitative aspects of physical sciences is that physical quantities such as distances, time intervals, etc., are represented by numerical quantities times their respective units and compared with others of the same kind by their numerical quantities. ..... One can say that the time interval between two instants is t times the second or simply t sec, the time between two other instants is t´sec´, etc., if the following conditions are satisfied:

> (1) The units of the observers have to be constant through the measurements.
> (2) The units of the observers have to be the same through the measurements.
> (3) The clocks of the observers (are understood) to be set to the same value zero effectively at the same instant (event or set of simultaneous events).

Let us note that (1)-(3) are not postulates, definitions, axioms, etc.; they are the most basic requirements (conditions) of physical sciences that have to be satisfied in representing physical quantities by numerical quantities times their respective units and comparing them with each other of the same kind by their numerical quantities. (3) is also the property (meaning) of synchronization of clocks.....

> We make a fundamental distinction between the following two cases:
> (a) when physical processes are measured from one and the same system and/or the physical processes move relative to one system, and
> (b) when the physical processes move relative to both systems.

.....

So far, we have considered the case (a). Let us remember that almost all the measurements supporting the consequences of the Lorentz transformations came in each case from two or more physical processes as measured in the same system. No two relatively moving observers in two inertial systems have yet measured independently under similar circumstances the quantities $X = (x_1, x^2; t_1, t_2; u_1, u_2;.....)$ and $X´= (x_1´, x_2´; t_1´, t_2´; u_1´, u_2´;...)$ for distances, time intervals, velocities, etc.,, of the same process that moves relative to both observers at the same two (instant) events 1 and 2 of the process and verified the properties of the Lorentz transformations. Hence, the claim that the usual interpretation is verified is incorrect. It may be that the consequences of the Lorentz transformations are, in general, valid for physical processes as observed in each case from the same system; to that extent only the Lorentz transformations are so far verified. We may say that the Lorentz transformations are just mathematical devices that enable one to obtain the laws of physical processes as observed in any one inertial system. It means that the case (b) is excluded. However, the usual interpretation assumes that the Lorentz transformations are also valid for the general case (b)."

Theimer, W., "Die Relativitätstheorie: Lehre-Wirkung-Kritik", Francke Verlag, Berlin, 1977

"The theory of relativity is a system of ´sliding´ units of measurement (Louis Essen, 1971, "The Special Theory of Relativity: A Critical Analysis", Oxford University Press). Lengths and time are measured in units varying with v2/c2. Einstein didn´t discover length-contraction and time-dilation in nature. He postulated these pseudo-effects, in order to justify the postulate c = constant about the velocity of light.....
All paradoxal consequences of "special" relativity follow from this constancy and finiteness of the velocity of light; they are by no means features of physical systems/objects.

.....

The considerations connected with the paths of light signals show that the supposedly banished absolute time has always been present in Einstein´s mind. This is the hereditary deffect, already encountered in the adjustment of distant clocks by means of light signals.

.....

The uniform relative velocity v between two moving systems, of vital importance for the very definition of relative motion, relies upon the silent assumption that a universal, absolute time, as well as an absolute length exist; indeed, v = dx/dt , x and t are taken identical by the two relatively moving observers. Otherwise the relative velocity wouldn´t be reciprocal.

The fundamental concept of inertial reference frame is defined through Newton´s law of inertia, which in turn, relies upon absolute space. Both inertial system and its velocity v are tought in absolute space.....

All measurements called up by Einstein are done with instruments conceived and built on classical concepts. The initial contradictions are then further amplified."

Essen, Louis, "Relativity -joke or swindle?", Electronics & Wireless World, 1978; 1988, pp.126-127

"Some of your contributors find it difficult to accept my contention (EWW, Oct.1978) that Einstein´s theory of relativity is invalidated by its internal errors. Butterfield for example (EWW, Febr. 1987) denies that there is any ***duplication of units*** or any harm in obtaining results from thought-experiments.....
When Einstein wrote his paper, two of the units were those of length and time. Velocity was measured in terms of these units. Einstein defined the velocity of light as a universal constant and thus broke a fundamental rule of science."

CONCLUSION

The expediency of "adjustment of measurement units" in order to make the velocity of light propagation independent on the velocity of observer/detector, as well as to make relative velocity reciprocal, was a blatant violation of one of the most basic requirements of the physics-as-a-natural-science, namely the constancy of measurement units and standards.

While conceivable for abstract, *dimensionless,* mathematical parameters x, y, z, t, the Lorentz transformation is a physical impossibility if the same parameters and the velocity are *physical quantities,* defined as *numbers times units of measurement.*

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