On Seeing the Superluminals

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Since the time of Einstein, there has existed a not-so-visible community of serious scholars working on candidate revisions for Einstein’s Special Relativity Theory (SRT; 1905, 1907) in order to expand its scope beyond point particles and light signals, to handle complex systems; i.e., systems involving extended bodies, arbitrary accelerations and rotations, and speeds not necessarily limited to light speed. I am a member of that community, and this paper is partly some history about the community, and partly a progress report on my own researches.

1. Introduction

This paper responds to David Garelick’s paper “Particles Traveling Faster than the Speed of Light”, which is also in the conference program. That paper calls attention to the need for some revision to Einstein’s Special Relativity Theory (SRT) to accommodate the probable existence of superluminal particles. Some on-going work along those lines is discussed there. But the need is actually much broader than one paper can expose, and the response is much broader than one paper can convey. This paper seeks to not only respond to Garelick’s issue, but also expand the discussion and engage the audience even more.

Since the time of Einstein, there has existed a not-so-visible community of serious scholars working on candidate revisions for SRT. They have been motivated by the perception of paradoxes within SRT, by apparent limitations on its domain of applicability, by engineering challenges, and by a host of other factors.

I am today a member of the SRT ‘re-development’ community. I first had contact with it as a student at M.I.T. (a pretty respectable school). At that time, I did not recognize the unsettled situation that existed, and I did not get involved the problems that it revealed. I was too busy getting an education in orthodox physics, with only a small digression into electrical engineering. That was where the contact existed to be found - there, and in other engineering and technology departments at M.I.T. and other universities.
After graduation, available work opportunities were all in engineering, not physics *per se*, because the space race was on. My first work assignment had to do with ring laser gyroscopes, which are based on the Sagnac (1913) effect. My first interactions with engineering colleagues were over whether this sort of system could, or should, be part of the world described by SRT. I was sure the answer was ‘yes’, but the others thought ‘no’. Evidently, Einstein had thought ‘no’ too. When asked what the Sagnac effect had to do with SRT, his response had been ‘nothing’.

Later I got into many other photon-related, and hence SRT-related, projects, some of which even had a bit of government funding. It may have been *verboten* in the world of physics, but in the world of engineering, it was only pragmatic to think about revising Einstein’s SRT. The theory really needs that sort of attention in order to expand its scope beyond point particles and light signals, and into realistically complex systems; *i.e.*, systems involving extended bodies, arbitrary accelerations and rotations, and speeds not necessarily limited to light speed.

Eventually, I gave up on SRT as it exists today. The next Section reviews the problem that drove me over the edge. I joined the dissenters. They were organizing journals: Galilean Electrodynamics, Physics Essays, Apieron, Toth Maatian Review; and newsletters: Common Sense Science, Meta Research Bulletin; and conferences: Physical Interpretations of Relativity Theory, Natural Philosophy Alliance, Alternative Natural Philosophy Association, Congresses in Russia and China.

Finally, I set up shop as a publisher for the community. I have been at that since 1997. Now, I think I know how the revision should go; subsequent Sections summarize the path I see. It begins with Einstein’s second postulate; namely, that light speed is a constant, now called \( c \), regardless of source or receiver motion, so long as the coordinate frame used is not accelerating. Revising that postulate to harmonize with phenomenology of the quantum-world, *i.e.* non-local action and time reversal symmetry, produces a covering theory that includes relationships from SRT, but with a broader context that admits, among other things, the superluminals.

### 2. My Upsetting Problem

What physicists believe today concerning the potentials and fields created by rapidly moving sources is expressed by the Liénard-Wiechert expressions for potentials and fields. Although Liénard (1898) and Wiechert (1901) worked independently of each other, and well before Einstein’s development of SRT [(1905), (1907)], their results agree with each other, and with SRT, because their derivations implicitly use the same assumption that Einstein later made explicit with his Second Postulate; namely, that light speed is the constant \( c \), independent of the velocity of the source, or receiver, requiring only that the reference frame used be not rotating or otherwise accelerating.

Their derivations being consistent with Einstein’s second postulate, the Liénard and Wiechert results are today incorporated into the body of knowledge constituting SRT. Expressed in Gaussian units [Jackson (1962)], the Liénard-Wiechert scalar and vector potentials are

\[
\Phi(x,t) = e^{[1 / \kappa R]}_{\text{retarded}} \quad \text{and} \quad A(x,t) = e^{[\beta / \kappa R]}_{\text{retarded}},
\]

where

\[
\kappa = 1 - n \cdot \hat{\beta}, \quad \hat{\beta} \quad \text{is source velocity normalized by} \quad c, \quad \text{and} \quad n = \frac{R}{R} \quad \text{(a unit vector)},
\]
The Liènard-Wiechert fields expressed in Gaussian units are then
\[
E(x,t) = e^{-(n - \tilde{\beta})(1 - \beta^2)/\kappa^2 R^2 + n \times (n - \tilde{\beta}) \times d\tilde{\beta} / dt} \frac{\kappa^2 R^2_{\text{retarded}}}{c^2}
\]
and
\[
B(x,t) = n_{\text{retarded}} \times E(x,t)
\]
The Liènard-Wiechert fields have some interesting properties. The \(1/R\) fields are radiation fields, and they make a Poynting vector that lies along \(n_{\text{retarded}}\):
\[
P = E_{\text{radiative}} \times B_{\text{radiative}}
\]
\[
= E_{\text{radiative}} \times (n_{\text{retarded}} \times E_{\text{radiative}}) = E_{\text{radiative}}^2
\]
But the \(1/R^2\) fields are Coulomb-Ampere fields, and the Coulomb field does not lie along \(n_{\text{retarded}}\) as one might naively expect; instead, it lies along \((n - \tilde{\beta})_{\text{retarded}}\).
Consider the following scenario, designed specifically for an instructive exercise in \textit{reductio ad absurdum}. A source executes a motion comprising two components: 1) inertial motion at constant \(\tilde{\beta}\), plus 2) oscillatory motion at small amplitude and high frequency, so that there exists a small velocity \(\Delta \tilde{\beta}_{\text{retarded}}\) and a not-so-small acceleration \(d\Delta \tilde{\beta}/dt\)\(\text{retarded}\). The absurdity is that the radiation and the Coulomb attraction/repulsion come from different directions. The radiation comes along \(n_{\text{retarded}}\) from the retarded source position, but the Coulomb attraction/repulsion lies along \((n - \tilde{\beta})_{\text{retarded}}\), which is basically \(n_{\text{retarded}}\) projected, and lies nearly along \(n_{\text{present}}\). This behavior seems peculiar. But all standard textbooks affirm that you simply have to believe in it - if you believe Einstein in all particulars. I was not personally able to believe in the predicted behavior, and so I was not able to believe Einstein in all particulars.

3. Revising SRT

So far, the only apparent way out of the sort of dilemma described above has been to investigate alternative founding postulates for developing theories that can be alternatives to SRT. My friends Prof. Parry Moon and Prof. Dominia Eberle Spencer and their son Euclid have pursued such researches for the last fifty years. Prof. Moon was that first contact with the SRT dissident community whom I mentioned finding at M.I.T. Prof. Spencer continues their joint work today (2005).
In (1956) Moon and Spencer first considered that light retains a connection with its source throughout the propagation process, which means that the ‘\(c\)’ remains relative to the source, regardless of how the source may move during the propagation process. This is not the Ritz Postulate (1908), or any other previously familiar postulate. It is a real innovation. Now refined to ‘Postulate III*’ (1990), it has been very successful in
many applications. Prof. Spencer wrote about the Hering furnace, overhead welding, the Faraday unipolar generator, and several more recent EM experiments discussed by Peter and Neil Graneau (1996) and by George Curé (2002). The Moon-Spencer assumption is that the light-speed postulate governs all electromagnetic interactions – a position I endorse. But so far, my own ‘upsetting problem’ has not been among the applications successfully treated. So I have kept investigating additional modifications to Postulate III* that might resolve my own upsetting problem, while not sacrificing the successes with all the other problems.

I believe the key idea in Postulate III* is the ongoing attachment of light to matter: propagation proceeds at speed $c$ relative to matter. But I also believe there should be symmetry with respect to source and receiver: the reception process should be just a time-reversed version of the emission process. So my current best postulate is that light propagation consists of two phases: 1) expansion from the source, attached to the receiver, followed by 2) collapse to the receiver, attached to the receiver. Figure 1 illustrates this two-step propagation process.

In Fig. 1, light is represented as an arrow, first expanding, and then contracting, over time $T$. The arrows on Fig. 1 should not be taken too literally. There is no implied assertion that light exists within a spatial volume of great length and small cross-section. We have no knowledge about cross-section, and it doesn’t enter the subsequent mathematics. There is also no implied assertion about the direction of propagation being pre-determined. It is presumably quite random. Any real physical system sheds many photons into many directions. The arrows on Fig. 1 just represent one of the many photons shed. There is finally no implied assertion about the receiver being pre-determined. The receiver illustrated on Fig. 1 is just one of many possible receivers, any one of which might have been the one hit, had the random propagation direction been different. These are all misconceptions that I have previously encountered while explaining Fig. 1.

In Fig. 1, the centroid of the light arrow always travels at speed $c$ relative to its matter attachment, the source or the receiver, and not relative to any aether or ether. The time required for the propagation process is determined by the length of the arrow at the mid point of the scenario, where the arrow is longest, where the expansion from the source switches to the collapse to the receiver. The time required for propagation is this longest arrow length divided by $c$. The emission phase and the reception phase of the propagation process each take half the total propagation time.

I call this postulated process ‘Two-Step Light’. Because of the history and the personalities involved, I like to think of Postulate III* as the maternal postulate, and Two-Step Light as the daughter postulate. Both are part of an on-going evolution, and neither will likely be the final postulate to be tried. Both leave questions. For example, consider the switch of attachment from source system $A$ to receiver system $B$: how does the release from $A$ and attachment to $B$ happen, simultaneously and instantaneously, at time $t_1$? We do not know. We just investigate what would be the implications, if that were temporarily assumed to be the case. In addition, without the Two-Step Light symmetrization of the Postulate III* scenario, one would also have to wonder how the light energy not only detaches from system $A$ at $t_1$, but also appears
entirely delivered at system B at time $T_1$, without any further delay. So we do have a little conceptual progress with Two-Step Light, although admittedly not awfully much.

Here is how Two-Step light resolves my original upsetting problem about the Liénard-Wiechert fields. Because of the various $2c$'s in the mathematics, the radiation direction $\mathbf{n}_{\text{retarded}}$ changes to $\mathbf{n}_{\text{half retarded}}$, and the Coulomb attraction/repulsion direction $(\mathbf{n}_{\text{retarded}})_{\text{projected}}$ changes to $(\mathbf{n}_{\text{retarded}})_{\text{half projected}}$. These two directions are now physically the same. So I am no longer upset. I am now encouraged.

But what about superluminal speeds in a Universe with Two-Step Light? I won’t dwell on algebraic derivations yet [see Whitney (2005)], but will just display the most interesting results concerning speeds in general, and superluminal speeds in particular.

The theory of Two-Step Light leads to separation of three distinct speed concepts: 1) Galilean speed $V$ (familiar for at least 400 years, conceptually unlimited, could be superluminal); Einsteinian speed $v$ (mysteriously limited to $c$, familiar for just over 100 years); 3) covariant speed $V^\uparrow$ (approaches infinity when $v$ approaches $c$, a frequently used part of SRT). SRT does not make a distinction between $V$ and $v$. Instead, it conflates the two, producing much unnecessary mystery and confusion. By separating the two concepts, the Two-Step Light theory becomes a “covering theory” for SRT. That is, it contains all the same equations, but also provides for them a broader context and better verbal interpretations. It shows how any scenario described...
in terms of Einsteinian speed or covariant speed can also be described **equally well** in terms of Galilean speed.

There exist formal relationships among the three speed concepts. The pattern followed is displayed in Table 1.

<table>
<thead>
<tr>
<th>function variable</th>
<th>$v$</th>
<th>$V$</th>
<th>$V^\uparrow$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v$</td>
<td>$(v)$</td>
<td>$v/(1-v\delta)$</td>
<td>$v/(1-2v\delta)$</td>
</tr>
<tr>
<td>$V$</td>
<td>$V/(1+V\delta)$</td>
<td>$(V)$</td>
<td>$V/(1-V\delta)$</td>
</tr>
<tr>
<td>$V^\uparrow$</td>
<td>$V^\uparrow/(1+2V^\uparrow\delta)$</td>
<td>$V^\uparrow/(1+V^\uparrow\delta)$</td>
<td>$(V^\uparrow)$</td>
</tr>
</tbody>
</table>

Solving for $\delta$ in terms of the variable required in each box produces explicit functional relationships among the three speed concepts. These are displayed in Table 2.

<table>
<thead>
<tr>
<th>function variable</th>
<th>$v$</th>
<th>$V$</th>
<th>$V^\uparrow$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v$</td>
<td>$(v)$</td>
<td>$2v\sqrt{1-v^2/c^2}$</td>
<td>$v\sqrt{1-v^2/c^2}$</td>
</tr>
<tr>
<td>$V$</td>
<td>$V/(1+V^2/4c^2)$</td>
<td>$(V)$</td>
<td>$V/(1-V^2/4c^2)$</td>
</tr>
<tr>
<td>$V^\uparrow$</td>
<td>$V^\uparrow\sqrt{1+(V^\uparrow)^2/c^2}$</td>
<td>$2V^\uparrow\sqrt{1+(V^\uparrow)^2/c^2}$</td>
<td>$(V^\uparrow)$</td>
</tr>
</tbody>
</table>

Using Table 2, one can calculate the numerical relationships among the three speed concepts. Figure 2 shows these relationships for Galilean $V$ up to $5c$. Observe that Einsteinian $v$ is limited to $c$, achieving that value at $V=2c$, and declining thereafter. Covariant $V^\uparrow$ has a singularity at $V=2c$, *i.e.* $v=c$, as is well known. It turns negative after that, but I have plotted its magnitude, choosing to interpret the negative sign as a direction reversal, rather than 'negative speed'.
4. Caution: Measuring Speed is not Trivial

Physicists sometimes measure speed by timing of received light signal pulses or other EM signals. That is feasible in a laboratory setting where the source is at hand and controllable. But often we are looking at a distant and uncontrollable source like a star, which does not deign to send pulses. In that case, we rely on Doppler shift of known source frequency. In either case, it seems always to be necessary to have in hand an ironclad assumption concerning the manner in which light propagates. But the present research contests Einstein’s postulate on the matter, so the matter cannot be considered settled, and no assumption can be considered ironclad.

One example of speed estimation implicitly relying on assumptions about EM signal propagation would be the now famous Bertozzi experiment (1964) designed to provide hard evidence about all speeds being limited by light speed $c$. With Two-Step Light, one needs to correct all signals for the mismatch between the physical process of light propagation and the mathematical model thereof by using ‘effective light speeds’ [Whitney (2005)].

$$c_{\text{arriving from retreating source}} = c/ (1 + V / 4c) \tag{1a}$$

$$c_{\text{going to retreating receiver}} = c/ (1 - V / 4c) \tag{1b}$$

Failure to apply the needed corrections to light speed produces a wrong estimate of particle speed; namely, the limited Einsteinian speed $v$ instead of the unlimited Galilean speed $V$.

The Doppler-shift scenario is involved, for example, in estimating the recession speeds of distant stars and galaxies. There is a hot current problem with the receding-star
scenario: the Universe appears to be speeding up. [Riess et al., (1998)] In the star scenario, we have approximately that source speed, receiver speed, and propagation direction are all aligned, and the source is in recession from the observer. Extracting a speed estimate from Doppler measurements requires an estimation equation. The one in current use is based on Einstein’s SRT; it goes

\[ v = v_0 \times \sqrt{(1 - v/c)/(1 + v/c)} \]  

(2a)

where \( v \) is the Einsteinian relative speed between source and receiver. This Doppler formula yields

\[ v/c = (1 - (v/v_0)^2)/(1 + (v/v_0)^2) \]  

(2b)

which has the Einsteinian property of yielding \( v \) limited to \( c \). The SRT Doppler formula cannot yield an estimation formula that produces the unlimited Galilean \( V \). That would make the recession of distant stars look slower than it should be.

It appears that any kind of data, whether light pulse, EM signal, or spectral shift, if used along with the assumptions of SRT to estimate source speed, can yield only the Einsteinian \( v \). The broader message here is that ‘observations’ are never clear-cut. There is always some underlying phenomenon, some somewhat detached body of data about it, and some body of assumptions about how the phenomenon created the data. Unraveling the true story about the phenomenon is never a risk-free process.

5. Concluding Comments

There is an important technology aspect to the on-going research into revising SRT [Wang & Hatch (2005)]. In the twentieth century, Einstein convinced us that Universal Time was impossible in a Universe that has different reference frame in relative motion with respect to each other. But in the twenty-first century, the existence of our successful GPS system seems to cry out: “Universal Time Yet Lives!” We know exactly how to implement it; we just don’t all agree on what it means [See Hatch (2004)].

Many of us involved in these researches believe that Universal Time is a meaningful concept, and want a theory that uses it. There are presently at least two schools of thought about how to use it. One holds that only one unique light-speed behavior, and hence only one unique light-speed postulate, can be consistent with Universal Time. The other holds that, whatever the light-speed behavior may be, if the postulate used to build a theory and design data processing algorithms properly reflects that behavior, then Universal Time can be defined and shared by all observers. I am of the second school of thought. To me, Universal Time seems more fundamental than any light-speed postulate.

If accurate, Two-Step Light Theory recovers Universal Time. It also fulfills several other goals that I think are important: 1) Theories should not unnecessarily involve an ether; 2) Testable physical predictions should not be framed in terms of absolute velocities; 3) Testable physical predictions ought not be observer-dependent; 4) Theories ought to be robust enough to work regardless of what velocity, acceleration, etc., any material particles exhibit.
Acknowledgments

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