Rebuttal of Arguments Published in "Studies in History and Philosophy of Modern Physics" Claiming that Special Relativity Is "*symmetric, physical and consistent*"

J. N. Percival, 1 (203) 438-9307 USA, NPercival@SNET.net
Semantech, 79 Haviland Rd., Ridgefield, CT 06877-2810, USA

ABSTRACT
This paper reviews the 100+ year dispute regarding the philosophical basis and physical interpretation of Einstein's special theory of relativity (STR). The Dingle-Popper debate is analyzed. Dingle asserted that STR could not be "*symmetric, physical and consistent*". Popper gave his rebuttal. More recently, Dotson also contested Dingle's claim. Taking Dotson's analysis to a much deeper level, it's shown that Dingle (and Einstein) were correct. In addition, careful analysis shows that one cannot consistently interpret STR's time dilation as describing actual proper time accumulation. Further still, STR's time dilation equation even when interpreted as describing "just observed" time is not consistent with GPS data.

Category: physics.hist-ph

Keywords:
Dingle
Popper
Twin Paradox
time dilation
Special relativity
Lorentz relativity
GPS

1. Introduction

In the Dingle-Popper debate, Herbert Dingle asserted that STR could not be "*symmetric, physical and consistent*". Karl Popper argued that it could be such. Peter Hayes (2010) analyzed Popper's response to Dingle on that matter, as well as other issues, and argued in support of the conclusions of Dingle. The paper by Dotson (2012) in Studies in History and Philosophy of Modern Physics, tries to rebut the conclusions of Dingle and Hayes. This paper argues that the paper by Dotson is incorrect in its conclusion. The issue examined is the long standing debate regarding the physical interpretation of STR – specifically it addresses the question "*Does STR's Time Dilation equation describe an asymmetric physical slowing of proper time accumulation?*"

In addition, Dotson (2012), halfway through section 5, responds "*to Dingle objections*" to Popper's answer to "The Question" that Dingle posed. Again, Dotson's rebuttal of Dingle is shown to be flawed.

2. Background – Drawing on the Twin Paradox to understand what Dingle meant by "physical"

First, we will review the history of the Twin Paradox, particularly as it relates to Herbert Dingle so as to illustrate the dichotomy of "just observed" and "physical".

Einstein (1905) developed the basis for special relativity. Einstein derived the time dilation equation which was symmetric and applied equally to all inertial frames and inertial observers and their clocks. This seemed to imply that the equation was describing a symmetric, "just observed" effect, namely, that A would (just) observe B's clocks as running slow and B would (just) observe A's clocks as running slow. Thus, critics rebelled when Einstein continued and claimed that the time dilation equation implied that if two clocks started together and one clock made a round trip, the traveling clock would have accumulated less proper time than the stay-at-home clock as this was an **a**symmetric, invariant, physical effect.

H. Chang (1994) gives an excellent review of the Twin Paradox and of the evolution of Dingle's thinking which makes clear what Dingle means by "physical". Chang (1994) explains that Dingle was an ardent and well regarded supporter of STR for quite some time and then he started analyzing the Twin Paradox. Dingle first asserted that STR did not predict a net proper time difference but rather predicted that inertial observers would just observe each other's clocks as having slower clock rates and there would be no net proper time difference. At this stage, Dingle was not contending that STR was invalid, but rather was claiming that STR had been misinterpreted to be describing what was happening physically. However, after debating with his peers, Dingle concluded that the prevailing and necessary interpretation of STR was that it *was* describing what was happening physically and, therefore, because it was based on relative velocity and was inherently symmetric, STR could not be consistent. This, as documented by Chang (1994), stirred up a lot of controversy and criticism of Dingle. (Ironically, Dingle's critics seemed out of sync with Einstein as Einstein had abandoned explaining the (physical) net proper time difference in terms of STR decades earlier - Einstein (1916, 1916, 1918), Sachs (1985), Unnikrishnan (2005).)

Dingle's discussions with Popper were a continuation of that later Dingle view. Regarding STR's time dilation, Dingle (1972) put it this way, "… *the theory unavoidably requires that clock A works more slowly than B and clock B more slowly than A --which it requires no super-intelligence to see is impossible*."

The author has elsewhere discussed the Twin Paradox from many different angles (Percival 1994-2012) including the main topic of this paper with the last paper and the 2010 web site also addressing the relevant empirical evidence.

3. Conceptual analysis of Dotson's analysis of the Dingle-Popper Scenario

Hence, in the context of Dingle's meaning of "physical", the assertion that STR's time dilation equation should be interpreted as saying that clocks in K run physically slow with respect to clocks in L AND clocks in L run physically slow with respect to clocks in K is not just counterintuitive but counter-logical.

Dotson, in addressing the question of "*Is STR a symmetric, consistent, physical theory?*", did NOT do the analysis in the context of a single scenario, as one would naturally expect, to show the two observers' views were physically compatible. Instead, Dotson analyzed two separate scenarios, one from K's perspective and one from L's perspective, thus side stepping the key issue of physical consistency. (Dotson (2012), in section 4, first paragraph on page 67, tries to justify the separation of the two analyses by invoking relative simultaneity and by arguing for the need to separately set initial conditions to zero. Neither is a valid justification.)

The two separate analyses showed nothing about the consistency of STR in the context of the Dingle-Popper discussion. Both Dotson analyses merely showed that if one used SRT to **calculate** comparative clock rates, the results would be consistent with STR. Hence, the question remained are these calculations consistent with the physical world.

4. Analyzing A Single Scenario With SRT From Different Frames

We will analyze a simplified, single scenario. We have three identical clocks at rest together in frame O. These three clocks are synchronized to 0. Then we have clocks K and L accelerate to velocity v relative to frame O in opposite directions. When clock K reads 5,000, it reverses direction and travels back to the original starting point in O at speed v (in the opposite direction of its outbound trip). Similarly, when clock L reads 5,000, it reverses direction and travels back to the original starting point in O at speed v (in the opposite direction of its outbound trip). When the 3 clocks have an arbitrarily close near miss at the original origin in O, all 3 read the other 2 clocks – since they are arbitrarily close, there's no relative simultaneity effect in these readings. Now, what does STR predict for these readings at the start and end of this scenario? In this case, the difference between the readings of each clock at the start and the end represent the amount of proper time accumulated between the two events of the start and the end of the scenario for each of the 3 clocks. Note that, using STR, there is perfect symmetry for K's and L's trips except for direction and, using STR, effects are not direction dependent.

So what does O, using STR, predict about the proper time recorded by the 3 clocks? O observes perfect symmetry between the K and L trips (i.e., the same relative velocity between the two events of start and end). Hence, O using STR, predicts that L and K will have had the same "time dilation" effect vis a vis O's clock. Hence, if STR "time dilation" is to be interpreted as describing an (asymmetric) physical slowing, **O, using STR, will predict that the K clock and the L clock will have accumulated less proper time by exactly the same amount relative to his own clock (O).**

So what does K, using STR, predict about the proper time recorded by the 3 clocks? K notes that he's had relative velocity between both of the other clocks for the whole trip and that his relative velocity between him and L has been greater than the relative velocity between him and O for the whole trip. Therefore, **K, using STR, will predict that the O clock will have accumulated less proper time relative to his own clock (K) and that the L clock will have accumulated even less proper time relative to his own clock (K).**

So what does L, using STR, predict about the proper time recorded by the 3 clocks? L notes that he's had relative velocity between both of the other clocks for the whole trip and that his relative velocity between him and K has been greater than the relative velocity between him and O for the whole trip. Therefore, **L, using STR, will predict that the O clock will have accumulated less proper time relative to his own clock (L) and that the K clock will have accumulated even less proper time relative to his own clock (L).**

Hence, we see that we cannot interpret STR's time dilation equation as describing a physical slowing of proper time accumulation as that interpretation would lead to 3 contradictory results for the proper time accumulated on the clocks between two well-defined events and proper time is an absolute physical entity that needs to be single valued and observer independent.

5. The Data Shows There Is Physical, Asymmetric, Velocity Dependent Clock Slowing

The reader might be inclined to just think, "*Well, the data supports STR to the nth degree so I need not concern myself with the above.*" However, careful analysis of the data doesn't support that view. Further, if we reflect on the history of STR development, we can be more open minded about what the data is telling us. Prior to Einstein's 1905 paper that laid the foundation for STR, Lorentz had developed his Lorentz Aether Theory (LAT) which contended that there was physical asymmetric clock retardation as a function of velocity with respect to a single preferred frame. We need not endorse LAT but just be open to the concept of asymmetric, physical clock retardation as a function of velocity with respect to a specific frame – again, not necessarily an "aether frame".

5.1 Particle Accelerators

Data on "time dilation" from accelerators, both linear and nonlinear, has shown the "time dilation" effect exists whether or not the observer and/or the observed are in inertial frames and the effect is a function of (instantaneous) velocity and not a function of acceleration per se (Misner (1973)).

The particle accelerator data was interpreted as confirming STR "to nine decimal places" and indeed it was consistent with STR to that degree of accuracy. However, one only got the perspective of the earth bound frame and one did not get data from the particle frame so particle accelerator data doesn't address the question of whether it's a "just observed", symmetric effect or a physical, **a**symmetric effect..

5.2 GPS

GPS, which is often claimed to be built on STR, actually uses the Lorentz Relativity model (Van Flandern (2003)) where the v in the "time dilation" equation is NOT the relative velocity of the two clocks being compared, but rather it is velocity with respect to a single, "preferred" frame, in this case, the Earth Centered Inertial (ECI) frame. In addition, in GPS we get clock data from two perspectives (satellite clocks and earthbound clocks) so we can finally see if the effects are symmetric or asymmetric. GPS shows us the velocity dependent effect is an **a**symmetric, physical effect and the "just observed" effect is also asymmetric so no interpretation of STR is supported. None of the GPS data on the velocity dependent effect (from the earthbound clocks' perspective) is consistent with STR and further data from the satellites' clocks' perspective show the opposite effect of what STR's time dilation predicts

GPS works to a very high degree of accuracy. In the latest application for the John Deere tractor company, precision to one or two centimeters is required so that the tractors will not damage the farmers' irrigation systems. If GPS changed how it calculated the velocity effect and used a frame other than the ECI frame, then the system would become more and more inaccurate as the difference between other frame and the ECI frame increased (Hatch (2008-2014)). One must use a single, "preferred" frame. Using STR's construct of relative velocity between an earthbound GPS clock and a satellite GPS clock would yield a different and less accurate result -.as shown in the scenario with clocks O, K and L above.

Hence, a viable physics explanation of the velocity dependent effect in GPS would seem to lie outside the domain of STR per the argument in section 4 above and the physics community

would do well to try to find a viable physics explanation of that effect. (Since GTR's gravitational potential time dilation effect is consistent with the GPS data, one might think that argues for using STR for the velocity dependent effect. However, Lorentz Relativity 's asymmetric time dilation would seem to be a better analog with and is more equivalent to GTR's asymmetric time dilation.)

5.3 Hafele-Keating Experiment

Like GPS, the Hafele-Keating experiment used a physical model built on physical asymmetric clock retardation as a function of velocity with respect to a unique frame, namely, the ECI (Earth Centered Inertial) frame (Hafele (1972)). As described above when discussing Lorentz clock retardation, the Hafele-Keating experiment used the velocity of the airborne clocks with respect to the ECI frame and the velocity of the earthbound clocks with respect to the ECI frame to determine how much each clock has slowed relative to a clock at rest in the ECI frame and then computes the ratio of those rates to compare the expected airborne clocks rates to the earthbound clock rates. As discussed above, even though one is using an equation that looks like Special Relativity time dilation and one is using velocity "relative" to the ECI frame one is NOT actually using Special Relativity time dilation. If one actually just used Special Relativity and measured the relative velocities of the airborne clocks, one would not compute what the data results were as discussed above. Hence, a viable physics explanation of the velocity dependent effect in Hafele-Keating would seem to lie outside the domain of STR per the argument in section 4 above.

5.4 Atmospheric Muon Half Life

The earthbound observer sees muons created in the upper atmosphere as byproducts of high energy cosmic ray proton impacts with atomic nuclei. Due to the thickness of the atmosphere and the very short half-life of the muon, very few such muons would be expected to reach the earth's surface (only 1 in every 10^{138}) if one ignored clock slowing. (Bailey (1979), Field (2008)) However, a great quantity of muons do reach the earth and even penetrate 100s of meters into the earth. This empirical result is interpreted as proof of Special Relativity's (symmetric) time dilation, but this is not a logically consistent interpretation. It's claimed that time dilation, in effect, gives the muon's "clock" much more time for the "high speed" muon to decay and that gives the muon more time to traverse the depth of the earth's atmosphere (For a set of 10 GeV muons, 3.5% would be expected to reach the surface when asymmetric "time dilation"/clock retardation is taken into account.). (Bailey (1979), Field (2008))

To be consistent with Special Relativity, it is claimed that from the high speed muon's frame, it would appear that muons that are moving slowly with respect to the earth would be observed to have a much longer decay rate. The fact that, according to Special Relativity, both sets of clocks observe the other set to be running slow can allegedly be explained in terms of relative simultaneity and the different views of what's simultaneous with the event of muon creation in the upper atmosphere and the event of that muon reaching the earth. However, since this phenomenon involves a threshold event, namely, the decay or non-decay of the muon, the phenomenon cannot be explained by relative simultaneity or in terms of Special Relativity - this is a consideration for any velocity dependent effect that involves a threshold.

In the current case, either the muons are traveling at greater than the speed of light in the earth

frame, which is not consistent with Special Relativity, or their half-life has been physically and asymmetrically extended between the event of being created in the upper atmosphere and the event of reaching the earth. The asymmetry is established NOT by the earth observer determining the time between the two events of muon creation and the muon reaching the earth and then concluding the muon's clock is running slow. Instead, the asymmetric slowing is based on two absolute facts. We note that the atmosphere is approximately 20km thick and since the maximum speed for the muon is at most c (299,792,458 meters per second), that means it would take approximately 667μs for the fastest muon to traverse the entire thickness of the atmosphere. However, the mean lifetime of a muon at rest in the earth frame is just 2.2μs so the "high speed" muon clocks must be slowed by a factor of 300 or more, on average, to reach the surface of the earth. (Field (2008)) (While we discuss the logic in terms of a single muon, it also holds when viewed as a statistical argument about a large set of muons.) Thus, the asymmetric physical slowing is established by using two absolute facts, namely, the upper limit speed of c (according to Special Relativity) and the fact that a large number and significant percentage of these muons successfully survive their trip from the upper atmosphere to the surface of the earth and beyond. This asymmetric, physical slowing of clocks as a function of velocity with respect to the earth's frame cannot be explained by Special Relativity's constructs that are functions of (symmetric) relative velocity.

6. Dingle's Question

In section 5, Dotson wrote, "*A more general way to respond to Dingle's objections is to answer 'The Question' he posed to Popper: given two clocks in relative motion, STR demands that 'one clock must work steadily at a slower rate than the other. The theory provides no indication of which clock that is …*". Dotson then claimed, "*The clock on which the time interval between the two events is directly recorded is the one that will record the smaller time*."

As stated, Dotson's reply does not answer Dingle's Question. This shows once again how easy it is to erroneously mix proper time and observed time or calculated time. Dingle asks about physical proper time accumulation rates and Dotson answers mixing physical proper time and observed/calculated time. Dotson references the end of his section 1, where he discusses A′ passing first A and then B and recording all clock readings and uses this scenario to determine which frame has the slower clocks. However, we could equally well consider the scenario of A passing first A′ and then B′ and recording all clock readings and come to the opposite conclusion – using Dotson's criterion. Hence, Dotson has not answered Dingle's question, rather he has demonstrated how difficult (impossible?) it is to answer that question in the context of STR and its relative velocity construct.

As an aside, Einstein was correct in claiming that the twin who makes a round trip will lose proper time, however, after a century of analysis, almost all, including Einstein, agree that this velocity dependent effect is not caused by STR's time dilation or indeed by STR (Einstein (1916, 1916, 1918), Sachs (1985), Unnikrishnan (2005)).

7. Mindset

Dotson wrote in section 3 of his referenced paper, "*The special theory is counterintuitive in many of its predictions, but it never predicts magic. So the claim attributed to Dingle cannot be the right way to define symmetry in STR.*" Basically, this articulates the view that STR is correct,

therefore, by definition, any criticism of STR is inherently invalid. This attitude was often articulated regarding Dingle in the Twin Paradox debate as documented by McCausland (2011). Yet virtually all, including Einstein (see above), conceded, albeit tacitly, that Dingle was correct on that issue after all.

Admittedly, we are all confident that our current ideas are correct. Still the fact that this attitude was explicitly written as part of the rebuttal to Dingle's views may indicate that we should not be dismissive of criticism of STR before serious analysis including reviews of historically important debates about the philosophical foundations of currently accepted theory. The "STR is right by definition" view may be blocking an understanding of criticism that might show the way to a clearer, more consistent interpretation of STR and/or a more accurate interpretation of clock rate data.

The "Studies in History and Philosophy of Modern Physics" (SHPMP) journal rejected this paper which was rebutting the rather transparent problems in the paper they published by Dotson. Their rejection did not specify any specific problems with this paper. It simply said, "*SHPMP has adopted the policy not to publish papers that discuss the correctness or consistency of the special theory of relativity.*" This was interesting since the paper that SHPMP had published and that this paper was rebutting discussed "*the correctness or consistency of the special theory of relativity*" to exactly the same degree as this paper – the key difference was that the paper SHPMP published argued for STR and had some glaring errors that indicated that serious analysis of its correctness was not done. So I again direct the reader to the last sentence of the prior paragraph.

8. Additional Online Reading

The website at http://TwinParadox.net also deals with many of the issues discussed in this paper as well as other topics of related interest. Besides the Home page, review of the empirical data on clock retardation, these pages may be of interest: Open Letter On Special Relativity, An Open Letter to the Physics Community: The Twin Paradox, Report, Mainstream Response, Dingle's Question.

9. Conclusion

A detailed analysis of the Dingle-Popper debate confirms that STR's symmetric time dilation equation does not, in general, describe what's happening physically. This is an important finding as the data shows that, in the vicinity of the earth, clocks' proper time accumulation rates physically slow as a function of velocity with respect to a unique frame, the ECI frame. Hence, GPS, a system that is known to work well and with great precision, has produced data that is not consistent with currently accepted physics, namely, STR. Such mismatches between empirical data and currently accepted theory have often led to great advances in physics in the past when those mismatches were taken seriously.

Acknowledgement

Thanks to Ron Hatch, one of the most knowledgeable people in the world about the working of GPS (28 GPS patents) and of GPS data, for reviewing and confirming the author's findings on GPS.

References

Bailey, J et al, “Final report on the CERN muon storage ring including the anomalous magnetic moment and the electric dipole moment of the muon, and a direct test of relativistic time dilation”, Nuclear Physics B **150**: 1–75. (1979).

Chang, H. (1993), “A Misunderstood Rebellion: the Twin-Paradox Controversy and Herbert Dingle’s Vision of Science”, Studies in History and Philosophy of Science, 24, 741–790.

Dingle, H. (1972), *Science at the Crossroads* (Martin Brian & O'Keeffe), 27-30, 45-46, 129 – 132. http://www.worldsci.org/php/index.php?tab0=Books&tab1=Display&id=269&tab=3

Dotson, A. C. (2012), “Popper and Dingle on special relativity and the issue of symmetry”, Studies in History and Philosophy of Modern Physics, 43, 64-68.

Einstein, A. (1905) "On the Electrodynamics of Moving Bodies", Annalen der Physik, 17 891.

Einstein, A. (1916) *Relativity: The Special and General Theory*, Springery.

Einstein, A. (1916), "The Foundation of the General Theory of Relativity", Annalen der Physik, 49 (7), 769-822.

Einstein, A. (1918) "Dialog about objections against the theory of relativity", Die Naturwissenschaften, 48, 697-702.

Field, J. H. (2009) “Muon decays in the Earth's atmosphere, time dilatation and relativity of simultaneity” arXiv http://arxiv.org/abs/physics/0606188

Hafele, J.C. and Keating, R.E. , "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains" Science **177**, 166 (1972).

Hatch, R (2008-2014). Correspondence between Hatch (28 GPS patents) and the author between 2008 and 2014.

Hayes, P. (2010), “Popper’s response to Dingle on special relativity and the problem of the observer”, Studies in History and Philosophy of Modern Physics, 41, 354-361.

McCausland, I. (2011), *A Scientific Adventure: Reflections on the Riddle of Relativity* (Roy C. Keys, Inc.), 25-62, 119-142.

Misner, C.W., Thorne, K.S. and Wheeler, J.A. , *Gravitation* (W.H. Freeman & Co., 1973), p. 1055

Percival, J. N. (1994) "An Asymmetric Model of Space-Time Built on Lorentz Geometry and the Resulting Extensions of Special Relativity", Physics Essays, Vol. 7, #2, pg. 203

Percival, J. N. (1995) "A Full Understanding of the Twin Paradox Requires an Extension of Special Relativity: The Twin Paradox Analyzed Using Two Different Space-Time Models", Physics Essays, Vol. 8, #1, pg. 29

Percival, J. N. (1998) "Special Relativity: 'Inconsistent' Or Just 'Incomplete'", Physics Essays, Vol. 11, 1, pg. 138

Percival, J. N. (1999) "The Extension of Special Relativity: Algebraic Equivalence For Observations Plus A New Prediction", Physics Essays, Vol. 12, #4, pg. 766

Percival, J. N. (2000) "Correcting The Flaw In Special Relativity That Leads To The Twin Paradox – Reflections on a Debate With I. J. Good And I. McCausland", Physics Essays, Vol. 13, #4, pg. 555

Percival, J. N. (2006) "A Very Doable Experiment For NASA To Look Inside The Twin Paradox", Physics Essays, Vol. 19, #1, pg. 3

Percival, J. N. (2010) "The Twin Paradox Project", http://TwinParadox.net

Percival, J. N. (2012) "Twin Paradox Project Update Including The Mainstream Response", Proceedings of the Natural Philosophy Alliance. Vol. 9, pg. 417

Percival, J. N. (2012) "Both The Twin Paradox And GPS Data Show The Need For Additional Physics ", Proceedings of PIRT Vol.8 - The Physics of Reality: Space, Time, Matter, Cosmos pg. 183

Sachs, M. (1985), "On Einstein's Later View of the Twin Paradox", Foundations of Physics, 15(9).

Unnikrishnan, C. S. (2005), "On Einstein's resolution of the twin clock paradox", Current Science, 89(12), 2009-2015. – see online (http://cs-test.ias.ac.in/cs/Download"s/article_39568.pdf)

Van Flandern, T. (2003), "What the Global Positioning System Tells Us about the Twin's Paradox", Aperion, 10 #1, 69-86. - http://www.worldsci.org/pdf/abstracts/abstracts_662.pdf