The Consistent Unification of Space and Time.

By

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ABSTRACT:

This paper will argue that the Special Theory of Relativity does not unify space and time consistently, and that the Lorenz-FitzGerald transformations, which Einstein inherited from his predecessors, H.A. Lorenz and G.F. FitzGerald, fail to show how space, as such, is contracted by time dilation for moving observers in inertial reference frames.

Keywords: Special Theory of Relativity; Lorenz-Fitzgerald transformations; space contraction; time dilation; inertial reference frames.

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[1]. Introduction.

The history of the Special Theory of Relativity may be summarised as follows: in 1887, Michelson and Morley performed their famous interferometer experiment (Michelson and Morley, 1887 [1]).

FitzGerald (1889 [2]) then followed this with his idea that, if all moving objects were foreshortened in the direction of their motion, this would account for the null result of Michelson and Morley's experiment, which had been expected to find a variable light-speed, but did not.

Lorenz worked on the problem during the 1890s, as did Larmor (1897 [3]), with Lorenz's theory reaching its final form in 1898 (Lorenz, 1898 [4]) and being expounded by Poincaré in 1900 (Poincaré,

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1900 [5]). The stage was set for Einstein (1905 [6]), and later, Minkowski (1909 [7]).

In the standard view, if there are two frames of reference with a common origin at $t = t' = 0$, (x, y, z, t) and (x', y', z', t') are the coordinates of an event in the unprimed and primed frames, respectively, and the primed frame is seen from the unprimed one as moving with a velocity v in the x-direction. In the form given them by Cottingham and Greenwood (2007 [8], p.21, slightly modified), and taking $\beta = v/c$, where c is the speed of light in vacuum, and $\gamma = (1 - \beta^2)^{-½}$, the transformations are:

$$x' = \gamma(x - vt) \; ; \; y' = y \; ; \; z' = z \; ;$$

$$ct' = \gamma(ct - \beta x) \; .$$

(Equations 1a-d.)

This paper will argue the case that Equations 1a and 1d are essentially correct (although 1a needs modification), but that 1b and 1c are not. Possible alternatives will be offered.

[2]. A Thought Experiment (*Gedankenexperiment*).

Imagine that you are travelling in a spacecraft at near-luminal speed in some remote part of space. Let us say that $\beta = 0.99$, and $\gamma = 7.088812$.

Here on Earth, we are used to space and time being separate concepts: we use rods, rulers, measuring lines and tapes, etc., to measure the former, and chronometers of one form or another, such as clocks, to measure the latter. The most frequently used measure of distance, at least outside the United States, is the metre (US/UK spelling, meter), defined in terms of c (Bureau International des Poids et Mesures [International Bureau of Weights and Measures, BIPM], no date, [9]).

We do not usually have to take light-speed into consideration when measuring distance, unless the distances are either very long, when, on Earth itself, for example, there would be a delay of 0.010626 s before someone on one side of the Earth received a radio signal broadcast by someone on the opposite side (assuming no delays because of the need to send the signal via satellite) or very short, in the case of sub-atomic distances (see Backerra, 2019 [10]).

This would not be the case if we were aboard the hypothetical spacecraft we mentioned above. If we wanted to measure the distances away from us of nearby objects we passed, *no matter in which direction they might be*, we might well do so by bouncing radar signals off them and measuring the time it took for them to return. However, if we did this, the value of the distance, divided by two, would be affected by time dilation.

What of more distant objects, such as stars, galaxies, and so on? On Earth, the distance of remote galaxies is determined using Hubble's Law (Hubble, 1929 [11]). Other astronomical distances, such as that of the Sun to the centre of the Milky Way Galaxy (taken to be the black hole at Sagittarius A*), require complex observation and calculation, of the kind undertaken by Eisenhauer *et al* (2003 [12]).

The principle for our intrepid astronauts, however, is the same. Whenever they measure distances, in whichever direction they measure them, those distances are reduced by the effect of time dilation.

The speed of light in vacuum is a constant; time, on the other hand, is relative, except at the cosmic scale, when, as Larmor (1927 [13], pp.52-53) noted, absolute time was indispensable, and Gödel (1949 [14], p.447) pointed out that the absence of absolute cosmic time would result in the existence of 'closed time-like curves' (CTCs) and the possibility of travel backwards in time, which would violate, not only the principle of causality[2], but the Law of the Conservation of Mass-Energy, and the Second Law of Thermodynamics. Many seem not to have noticed that Gödel was presenting his metric *in order to argue against its physical reality*, not to propose it as an accurate cosmic model.

It is apparent that, for the astronauts, the Universe will look very different to the way it does here on Earth, and that – consequently – the

[2] It is claimed that quantum mechanics violates the principle of causality: that is because those making this claim do not understand the difference between ontology, which deals with what *is*, on the one hand, and epistemology, which deals with what we can *perceive* of what is, on the other. The Heisenberg Uncertainty Principle limits the latter, and has nothing to say about the former. Jaki (1989 [15]), criticises Kant, as well as the advocates of the Copenhagen Interpretation of quantum mechanics, but the Königsburg philosopher would not have made that mistake, at least.

transformation of coordinates from one inertial reference frame (Earth) to the other (spacecraft) needs to be somewhat more radical than that proposed above:

$$ct_x' = \gamma(ct_x - vt) \; ; \; ct_y' = \gamma ct_y \; ; \; ct_z' = \gamma ct_z \; ;$$

$$ct' = \gamma(ct - vt_x) \; . \tag{2a-d.}$$

Here, t_x, t_y, t_z and their primed counterparts are the times taken by electromagnetic radiation, of one sort or another, to cross given distances, from the perspective of the Earth inertial reference frame, in the case of the unprimed times, and that of the spacecraft's inertial reference frame, in the case of the primed ones. The amended version exhibits a pleasing symmetry.

[3]. Conclusion.

Poincaré (in Poincaré, 1913 [16], p.300) defined the principle of relativity as the principle that:

> **'the laws of physical phenomena must be the same for a stationary observer as for an observer carried along in a uniform motion of translation; so that we have not and can not have any means of discerning whether or not we are carried along in such a motion.'**

Einstein was, of course, to extend this principle to observers in accelerated motion, as well as uniform motion (Einstein, 1915, 1987, 1997 [17]). However, Poincaré (in Poincaré, op.cit. [18]), also noted that Laplace's theory (stated in Laplace, 1798-1825 [19], pp.642-645) that gravity travelled many times faster than light (at least 100 million times faster, see p.645) was false, and that light-speed was an absolute (Poincaré [18], pp.308, 312n).

The combination of absolute speed (c) and relative local time ensures that local space must also be relative, and our hypothetical spacecraft's motion relative to the observers on Earth ensures that both the former's time *and* space is 'warped' from the perspective of the latter to an increasing degree, the closer their speed gets to *c*. The products of absolute time and *c* yield absolute cosmic space ordinates, but these are mostly irrelevant to our astronauts, as they are, for all but large-scale astronomical or cosmological purposes, to us here on Earth (see Melia, 2012 [20]; Melia and Shevchuk, 2012 [21]).

REFERENCES.

[1] Michelson, A.A. & Morley, E.W., 'On the Relative Motion of the Earth and the Luminiferous Ether,' *American Journal of Science* **s3-34(203)**, 1st November 1887, DOI: 10.2475/ajs.s3-34.203.333, https://ajsonline.org/article/62505.

[2] FitzGerald, G.F., 'The Ether and the Earth's Atmosphere,' *Science* **XIII(28):390**, 2nd May 1889 (issue date 17th May 1889), DOI: 10.1126/science.ns-13.328.390, https://zenodo.org/records/1448315.

[3] Larmor, J., 'A dynamical theory of the electric and luminiferous medium. – Part III. relations with material media,' *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* **190:205-300**, 1st January 1897, DOI: 10.1098/rsta.1897.0020, https://royalsocietypublishing.org/doi/epdf/10.1098/rsta.1897.0020.

[4] Lorenz, H.A., 'Simplified Theory of Electrical and Optical Phenomena in Moving Systems,' *Proceedings of the Royal Dutch Academy of Sciences (Koninklijke Nederlandsche Akademie van Wetenschappen)* **1:427-442**, 1898, BibCode: 1898KNAB....1..427L, https://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1898KNAB....1..427L&defaultprint=YES&filetype=.pdf.

[5] Poincaré, H., 'The Theory of Lorentz and the Principle of Reaction (*La Théorie de Lorentz et le principe de réaction*),' *Archives nèerlandaises des Sciences exactes et naturelles* **Series 2, 5:252-278**, 11th December 1900, trans. Lawrence, S., January 2008,

http://www.physicsinsights.org/poincare-1900.pdf.

[6] Einstein, A., 'On the Electrodynamics of Moving Bodies (*Zur Elektrodynamik bewegter Körper*),' *Annalen der Physik (Annals of Physics)* **17[322]:891-921**, 30th June 1905,
DOI: 10.1002/andp.19053221004,
https://www.fourmilab.ch/etexts/einstein/specrel/specrel.pdf (original volume number = 17; modern volume & DOI numbers included refer to the German text; English translation [Fourmilab] from Einstein's book, *The Principle of Relativity*, London: Methuen, 1923).

[7] Minkowski, H., 'Space and Time (*Raum und Zeit*),' *Jahresberichte der Deutschen Mathematiker-Vereinigung (Yearbook of the German Mathematical Association)*, 1909, Leipzig, Germany: BG Teubner; trans. Lewertoff, F. & Petkov, V., ed., Petkov, V., 2012, Montreal, Quebec, Canada: Minkowski Institute Press, pp.39-53, https://www.minkowskiinstitute.org/old/mip/MinkowskiFreemiumMIP2012.pdf.

[8] Cottingham, W.N. & Greenwood, D.A. (2007), *An Introduction to the Standard Model of Particle Physics*, 2nd Edition, Cambridge, UK: Cambridge University Press, ISBN: 978-0-521-85249-4, hdbk.

[9] Bureau International des Poids et Mesures (International Bureau of Weights and Measures), 'SI [*Système International*] base unit: metre (m),' no date, Sèvres Cedex, France: BIPM,
https://www.bipm.org/en/si-base-units/metre.

[10] Backerra, A.C.M., 'Relation between Planck's Constant and Speed of Light, Predicting Proton Radius More Accurately,' *Applied Physics Research* **11(5):1-9**, 30th September 2019,
DOI: 10.5539/apr.v11n5p1, E-ISSN: 1916-9647,
https://itammagnetics.com/wp-content/uploads/2020/08/9.-Planks-constant-velocity-of-light-and-proton-radius-Anna-Backerra-2019.pdf.

[11] Hubble, E., ‘A Relation between Distance and Radial Velocity among Extra-Galactic Nebulae,’ *Proceedings of the National Academy of Sciences of the United States of America* **15(3):168-173**, March 1929, DOI: 10.1073/pnas.15.3.168,
BibCode: 1929PNAS...15..168H,
https://www.pnas.org/doi/10.1073/pnas.15.3.168.

[12] Eisenhauer, F. *et al*, ‘A Geometric Determination of the Distance to the Galactic Center,’ *The Astrophysical Journal* **597(2):L121-L124**, 24th October 2003 (issue date 10th November 2003),
DOI: 10.1086/380188,
https://iopscience.iop.org/article/10.1086/380188/pdf.

[13] Larmor, J., ‘Newtonian Time Essential to Astronomy,’ *Nature* **119(2997):49-60**, 9th April 1927,
DOI: 10.1038/119049a0x, 119049a0x.pdf.

[14] Gödel, K., ‘An Example of a New Type of Cosmological Solutions [*sic*] of Einstein’s Field Equations of Gravitation,’ *Reviews of Modern Physics* **21(3):447-450**, July 1949,
DOI: 10.1103/RevModPhys.21.447,
https://journals.aps.org/rmp/pdf/10.1103/RevModPhys.21.447.

[15] Jaki, S.L. (1989), *God and the Cosmologists*, Edinburgh, Scotland, UK: Scottish Academic Press, ISBN: 0-7073-0585-3, pbk.

[16] Poincaré, H., ‘The History of Mathematical Physics,’ in Poincaré, H. (1913), *The Foundations of Science,* trans. Halstead, G.B., New York, NY, USA: The Science Press, Ch. VII, pp.297-302, https://en.wikisource.org/wiki/The_Foundations_of_Science/The_Value_of_Science/Chapter_7.

[17] Einstein, A., ‘On the General Theory of Relativity (*Zur allgemeinen Relativitätstheorie*),’ *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin (Reports of the Meetings of the Royal Prussian Academy of Sciences of Berlin)*, 4th November 1915, in Engel, A., trans. (1987, 1997), *The Collected*

Papers of Albert Einstein, Volume 6: The Berlin Years: Writings, 1914-1917, Princeton, New Jersey, USA: Princeton University Press, ISBN: 978-0-691-01734-1, Document 21, https://einsteinpapers.press.princeton.edu/vol6-trans/110.

[18] Poincaré, H., 'The Present Crisis of Mathematical Physics,' in Poincaré, H. (1913), op.cit., Ch. VIII, pp.303-313, https://en.wikisource.org/wiki/The_Foundations_of_Science/The_Value_of_Science/Chapter_8.

[19] Laplace, P.S. (1798-1825), *Traité de mécanique céleste (Treatise of celestial mechanics)*, Vol. IV, trans. Bowditch, N., 1839, Boston, Massachusetts, USA: Charles C. Little & James Brown, Publishers, Book X, Ch. VII, S.22, https://ia800204.us.archive.org/4/items/mcaniquecles04laplrich/mcaniquecles04laplrich.pdf.

[20] Melia, F., 'Cosmological redshift in Friedmann-Robertson-Walker metrics with constant space-time curvature,' *Monthly Notices of the Royal Astronomical Society (MNRAS)* **422(2):1418-1424**, 25th April 2012 (issue date May 2012), DOI: 10.1111/j.1365-2966.2012.20714.x, https://academic.oup.com/mnras/article/422/2/1418/1036317?login=false.

[21] Melia, F. & Shevchuk, A.S.H., 'The $R_{\mathrm{h}} = ct$ universe,' *MNRAS* **419(3):2579-2586**, 4th January 2012 (issue date January 2012), DOI: 10.1111/j.1365-2966.2011.19906.x, https://academic.oup.com/mnras/article/419/3/2579/1069736?login=false.