ISSN: 2754-4753

Journal of Physics & Optics Sciences

SCIENTIFIC Research and Community

Review Article

Open Access

Faster than Light and the Third Postulate of Special Relativity

Marcelo A Crotti[1]*, Angel Torregrosa Lillo[2] and Guillermo E Crotti[3]

[1]Senior Oil & Gas Consultant, Castelli, Prov Buenos Aires, Argentina

[2]San Vicente del Raspeig, Alicante, Spain

[3]Lecturer in Astronomy II, La Plata, Argentina

ABSTRACT

Through a very simple conceptual analysis and with the aid of a few numerical examples, it becomes evident that the possibility of traveling at speeds greater than that of electromagnetic waves (hereafter identified as **F**aster **T**han **L**ight or simply **FTL** travels) or the simple instantaneous transmission of information generates temporal paradoxes. Since such paradoxes and potential causality violations would imply the impossibility of **FTL** travel, it would be necessary to consider as an alternative the proposition of a privileged system that would inevitably lead to an absolute metric for both time and spatial dimensions.

The existence of a privileged reference system was originally proposed by Lorentz and Poincaré, in which the deformations of lengths and times between Inertial Systems (**IS**) are real, and the speed of light is only apparently constant as a result of these instrumental alterations [1,2].

This privileged system maintains the "superfluous" nature of the existence of a supporting medium intended to describe the reality of each **IS**. However, it compels us to assume the existence of a fundamental framework through which both waves and particles would propagate.

***Corresponding author**

Marcelo A Crotti, Senior Oil & Gas Consultant, Bolivar 1275, (7114) Castelli-Prov Buenos Aires- Argentina.

Received: August 13, 2024; **Accepted:** August 20, 2024; **Published:** September 19, 2024

Introduction

Among recent scientific news and speculations, the possibility of **FTL** travel is frequently mentioned. These proposals, often based on particular solutions to the equations of General Relativity, range from wormholes to special metrics [3,4].

However, the same authors who propose these possibilities seem unaware that their suggestions necessitate a reinterpretation of certain concepts related to the origins of **S**pecial **R**elativity **T**heory (**SRT**). In particular, this article analyzes the possibility and impact of absolute and universal synchronism that would be allowed by such travel, unrestricted by the value of "c".

Observations

A Third Postulate?

In his development of **SRT** in 1905, Einstein articulated two postulates [5].

1. The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems of co-ordinates in uniform translatory motion.
2. Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity c, whether the ray be emitted by a stationary or by a moving body. Hence:

$$Velocity = \frac{Light\ path}{Time\ interval}$$

where time interval is to be taken in the sense of the definition in § 1.

However, the second postulate implicitly includes a third "postulate" [6], as the definition of the time interval in § 1 employs the following terms:

*… We have so far defined only an "**A** time" and a "**B** time." We have not defined a common "time" for **A** and **B**, for the latter cannot be defined at all unless we establish **by definition** that the "time" required by light to travel from **A** to **B** equals the "time" it requires to travel from **B** to **A**".*

It is emphasized here that the equality of times in the round-trip journey of the light signal is not an experimental fact but a definition (equivalent to a fundamental postulate), necessary for establishing the synchronism of distant clocks and, as is evident later in the same publication, also necessary for deriving the Lorentz transformations, which are at the core of the calculations in Special Relativity.

In summary, this third postulate is what prevents the existence of privileged inertial observers for whom the speed of light is genuinely constant in round-trip journeys between two points within their own system. After this ***DEFINITION***, the constancy of "c" on one-way trips becomes the characteristic for ***ALL*** inertial systems.

It is easy to demonstrate that this definition is entirely compatible with the way electromagnetic interactions occur between rigid bodies, making it almost "intuitive" and "necessary", just as occurs with the Euclid postulates.

...Until the possibility of traveling and, therefore, transmitting information **FTL** "is considered.

Analysis

Before proceeding with the development, it may be appropriate to clarify that this article does not claim that **FTL** travel is possible. Here, we only analyze what would happen if such travel were possible.

Setting aside the work of science fiction authors, it is quite common to find articles written by specialists in relativity that explore the possibility of **FTL** travel. Although it may seem unnecessary to mention, we assume that these authors have considered the impact of their proposals on the foundations of **SRT**, however their analyses only include the consequences of their proposals, taking for granted that the original axioms need not be revisited even if paradoxical results are obtained.

Following these authors, we will imagine that **FTL** travel is possible, and for this purpose, we will use hypothetical spacecraft with the necessary power to travel from one point of the Cosmos to another at the desired own time. The mechanism of travel is irrelevant to this analysis, nor is it necessary for people or material objects to be transported. In fact, it is sufficient to transmit information instantaneously from any location in the Universe to another for the purpose of this study. The use of spacecraft and people is only to make the scenario easier to describe.

We will label travelers capable of instantaneously displacement (without consuming proper time during the transfer) as "**T**achyonic **T**ravelers" or simply **TT**.

Next, we will analyze a thought experiment involving the instantaneous travel of two **TT** belonging to different **IS**. For this purpose, we will assume that, in space, there is a **TT** (labeled as **E1**) at rest with respect to the Earth, and that the Earth itself represents an **IS**. For the latter, we assume that the effects of velocities and accelerations experienced by our planet as it moves through the Cosmos are negligible.

We will also assume that a second **TT** (called **Z1**) is approaching the position of **E1** inertially, at a speed of 0.866c (approximately 258,000 km/s) in the direction connecting the Sun with the stellar system of Alpha Centauri (α Cen), moving towards the latter.
In this framework, we conduct the following thought experiment: When traveler **Z1** reaches the position of **E1** both perform (each in their tachyonic spacecraft) an instantaneous journey to α Cen.

Note: Both travelers agree on the simultaneity of the initial event since they are at the same location at the time of departure.

We will analyze how the end of the journey unfolds employing different assumptions. Initially, there are two basic possibilities

- **First Possibility of Taquionic Travel:** Each traveler undertakes an "instantaneous" journey within their own coordinate system meaning that, in their **IS**, the date and time at α Cen is the same as it was near Earth at the moment of departure. In this case, as discussed in the following paragraphs, they do not arrive simultaneously at their destination.
- **Second Possibility of Taquionic Travel:** Both travelers depart simultaneously from the Earth position and also arrive together and simultaneously near α Cen.

The first possibility adheres to Einstein's 1905 framework. In this scenario, there would be a condition of an instantaneous phenomenon inherent to each **IS**, corresponding to the definition of simultaneity for distant events.

To facilitate the analysis, instead of using space-time diagrams with their lines of simultaneity, we will employ schematic images to illustrate the specific events.
Note: Space-time diagrams may be confusing for non-specialists because in instantaneous jumps, there are no paths or trajectories to be drawn in such schemes, as according to the definition of "instantaneous" (without proper time consumption), the transition from one image to the next occurs without intermediate stages. The same would happen to travelers **E1** and **Z1**. In the blink of an eye, their stellar surroundings would change without any record of intermediate images.

For simplicity, we will assume that the distance between the Sun and α Cen is four light-years and that the speed of light is 300,000 km/s. More precise numbers do not alter the conceptual part of the analysis.

Additionally, for simplicity, we assume that both travelers agree that the tachyonic jump occurs at 00:00:00 on January 1, 2100. While the calendar of each traveler may differ, for the sake of analysis, we consider them synchronized at the moment of departure. In fact, both travelers could have been synchronized in the Earth system and initiated the experiment by assuming that **Z1** accelerates (also instantaneously, without consuming their proper time) to become aligned with the other **IS**. In this way, he would begin the journey as part of the second **IS**, with their clock synchronized (only for that instant) with that of traveler **E1**.

Analysis of what occurred, according to E1

Figure 1 shows both **TT** at the moment of initiating the tachyonic transfer, as observed from Earth's **IS**.

In Figure 1, two auxiliary observers (**E2** and **Z2**) are included, who are synchronized with **E1** and **Z1** respectively. The clock readings of the four observers are also indicated, as recorded from Earth's **IS**. All values were calculated using the Lorentz Transformations

- $t' = (t - vx/c^2)\,\gamma$
- $x' = (x - vt)\,\gamma$
- $y' = y$
- $z' = z$
- Where $\gamma = 1/(1 - v^2/c^2)^{0.5}$

In these expressions, the variables on the left side of the equations correspond to values measured in the moving system, as observed from the system that considers itself at rest.

After the tachyonic jump, the situation, also described from Earth's **IS**, is shown in Figure 2.

For **E1** the arrival near α Cen is instantaneous, so he meets his inertial companion **E2** at the same time as his departure from Earth. Observer **Z2** is still at α Cen, but **Z1** has disappeared from the scene, having embarked on his tachyonic journey.

In fact, **E1** must remain at Alpha Centauri for more than three years to see **Z1** appear instantaneously and continue his inertial journey at 0.866c in the original direction. This situation is depicted in Figure 3.

Of course, **Z1**'s clock shows exactly the same time as it did when the tachyonic journey began. However, due to the desynchronization of clocks between observers from different **IS**, it took more than three years in the Earth - α Cen system for the **Z1** – **Z2** system to reach the indicated time near α Cen.

This situation, seemingly irreconcilable with logic, arises from the combination of relativistic synchronisms, the possibility of **FTL** travel, and the assumption that these journeys respect the synchronisms established using electromagnetic signals.

However, the situation may seem even stranger when analyzing the observations made by the other **TT**.

Analysis of What Occurred, According to Z1

Figure 4 shows both travelers at the moment of initiating the tachyonic transfer, as observed from the **IS** to which **Z1** and **Z2** belong.

In this case, the Sun - α Cen distance is only two light-years, and the Earth **IS** clock is significantly ahead for the traveler synchronized with **Z1**, near α Cen, whom we have identified as **Z3**, since the proper times and travel velocity prevent it from being the same as the one (**Z2**) who participated in the previous experiment.

At the end of his journey, **Z1** is faced with the striking observation that **E1** has been waiting for him at α Cen for approximately seven years, as confirmed by **Z2**, in accordance with what is shown in Figure 2, where **E2** time at α Cen coincides with the passage of **Z2** through that position. Therefore, these are simultaneous events given the coincidence in time and place.

The scenes depicted in Figures 1 and 2 enable the possibility of a temporal loop. If, before embarking on the tachyonic jump (on 01/01/2100 for both **TT**s), traveler **Z1** were to hand over a memory containing the data of events about his past few years to traveler **E1**, the latter could then pass the same memory to traveler **Z2** on 26/01/93!

If, later, **Z2** were to use his own tachyonic abilities, he could return the memory to **Z1** nearly seven years before **Z1** handed it to **E1**. In this way, **Z1** would possess a record of his future life describing the next seven years.

It becomes evident that this paradox only arises after considering what we call the **First Possibility of Tachyonic Travel**. At this point, it is important to note that this possibility would only be allowed if we assumed that, after each **TT** embarks on their journey, they continue to belong to the inertial system **IS** from which they departed. However, this assumption is quite fragile, as the traveler, due to their acceleration (whether extremely large or instantaneous) to **FTL** conditions, inevitably loses their inertial status. In this way, ceasing to belong to their initial **IS**, we may assume that all **TT**s join a singular physical structure (not governed by the laws of electromagnetic interactions), which immediately enables the so-called **Second Possibility of Tachyonic Travel**, where temporal paradoxes simply vanishes, and making the expression "at a given moment" acquire the meaning of absolute.

Summary of the Observations of E1 and Z1

From the preceding analysis, it must be concluded that if each **TT** fulfills the condition of simultaneity within their own **IS**, the cross-observations can be summarized as follows:

- According to **E1**, traveler **Z1** was "missing" for about three and a half years (beyond the possible detection of any observer belonging to the Earth - α Cen **IS**) before materializing at α Cen.
- According to **Z1**, traveler **E1** transported nearly seven years into the past while he made his instantaneous journey (barely a blink in his personal perception) to α Cen.

Either observation is highly counter-intuitive, but together they serve as a strong warning that the assumptions under which these analyses were conducted must be reconsidered.

As a first conclusion, the results obtained thus far, open two main possibilities

- **FTL** travel is impossible within the theoretical framework imposed by the laws of physics as we know them, as it could result in causality violations (where the effect occurs before the cause), which is unacceptable to the vast majority of scientific community.
- One or more of the initial assumptions must be revised to avoid causality violations.

If we do not lean towards the first option, the assumption we consider most fragile in the second option is the one identified as the third postulate of **SRT** at the beginning of this article, given that the equality of times taken by light in the going (**A→B**) and return (**B→A**) paths is not an experimental fact but a definition.
Note: It may be worth emphasizing that all measurements of "c" have been made using devices with round-trip paths for the light signal.

Of course, it is impossible to deny that the condition imposed by Einstein's 1905 definition allows for the correct equations to interpret electromagnetic interactions.

But, remarkably, this “postulate” could be modified without altering the logical consistency of all subsequent deductions leading to the Lorentz transformations.

As an example, if Einstein's original text were changed to
*… We have so far defined only an “**A** time” and a “**B** time.” We have not defined a common “time” for **A** and **B**, for the latter cannot be defined at all unless we assume **that inertial systems behave as if** the “time” required by light to travel from **A** to **B** equals the “time” it requires to travel from **B** to **A**.”…*

In that case, it could happen that the thought experiment proceeds such that the travelers arrive together at Alpha Centauri, only to discover that the arrival time on their clocks (or at least one of them) does not match that of **E1**, neither that of **Z1**. This would indicate the existence of a specific synchronization for these **FTL** transport methods and that the synchronizations within their own **IS** (based on the third postulate for each **TT**) do not describe physical reality. Conversely, that physical reality could only be revealed through travels not subject to the limitations experienced

by electromagnetic waves.

Discussion

Would this new definition of the third postulate change physics as we know it?

The answer is both, yes and no.

- Firstly, it would not change the description of electromagnetic interactions. Lorentz and Poincaré already demonstrated that both Maxwell's equations and the Lorentz transformations are compatible with this new wording of the third postulate [1,2].
- Secondly, it would become mandatory to consider the possibility of achieving absolute synchronization in the Universe, defined by the synchronization of **FTL** transport or communication methods.

The next inevitable question is: Is this approach compatible with the equations of **SRT**?

At this point, the answer is affirmative [7]. We would only need to revert the interpretation of the Lorentz Transformations to their initial development, known as "Lorentz and Poincaré Relativity," in which:

- The deformations of time and lengths are real and occur due to the interaction of moving systems relative to a supporting medium or an absolute reference system.
- The speed of light is only apparently constant for each **IS**, as a consequence of the deformation of any measurement system that uses electromagnetic phenomena in its construction.

At the end of the 19th century, it seemed necessary that electromagnetic waves required a supporting medium to propagate. However, this conception posed a serious problem: the law of inertia required that material particles pass through this medium without friction.

Today, the wave concept of matter allows us to conceive that "particles" (like electromagnetic signals) propagate through this medium rather than passing through it.

To improve the compatibility of this analysis with **SRT**, it would be interesting to clarify the use of units in each **IS**. In this sense it might be useful to replace the expression: "Light travels at 300,000 km/s in any **IS**" with something more specific, such as "Light travels at 300,000 km_A/s_A in-system **A**, at 300,000 km_B/s_B in system **B** and so on." Whenever length and time units are mentioned, it should be understood that they are the units specific to each **IS**.

Finally, it is worth noting that this approach is consistent with the analyses inherent in the theory of General Relativity, as Einstein himself stated in 1920 that a supporting medium is necessary for the spacetime of General Relativity to undergo deformations [8].

"*Recapitulating, we may say that* ***according to the general theory of relativity*** *space is endowed with physical qualities;* ***in this sense****, therefore,* ***there exists an ether****. According to the general theory of relativity space without ether is unthinkable; for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time*".

A. Einstein, Leiden, 1920

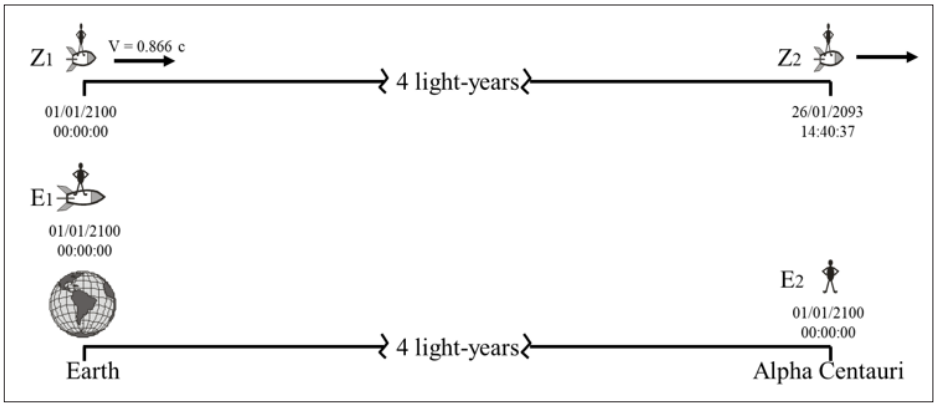

Figure 1: Start of the experiment as described from Earth's **IS**

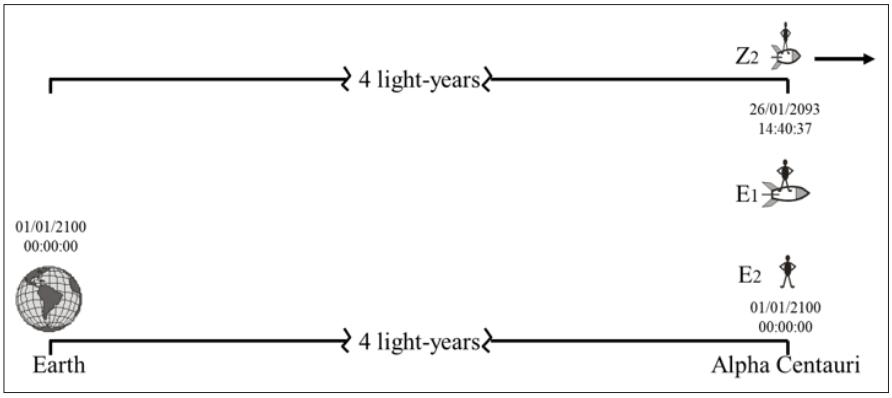

Figure 2: End of the experiment as described from the Earth - α Cen **IS**

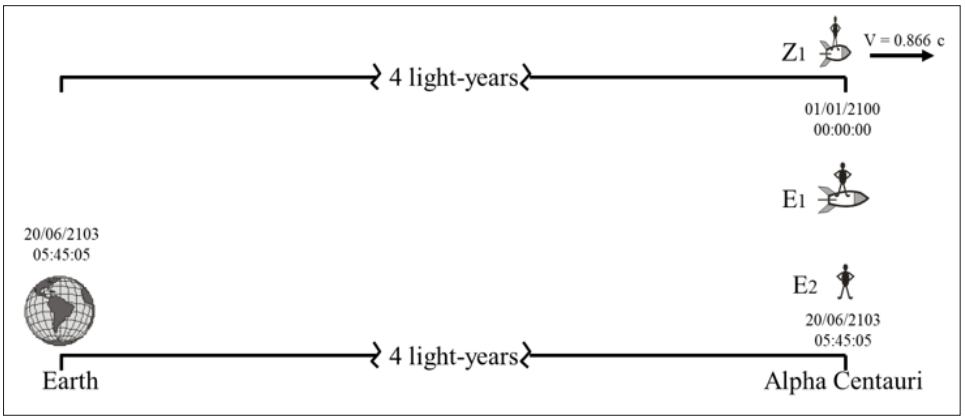

Figure 3: For observers in the Earth - α Cen **IS**, nearly three and a half years must pass for **Z1** to materialize instantaneously at α Cen

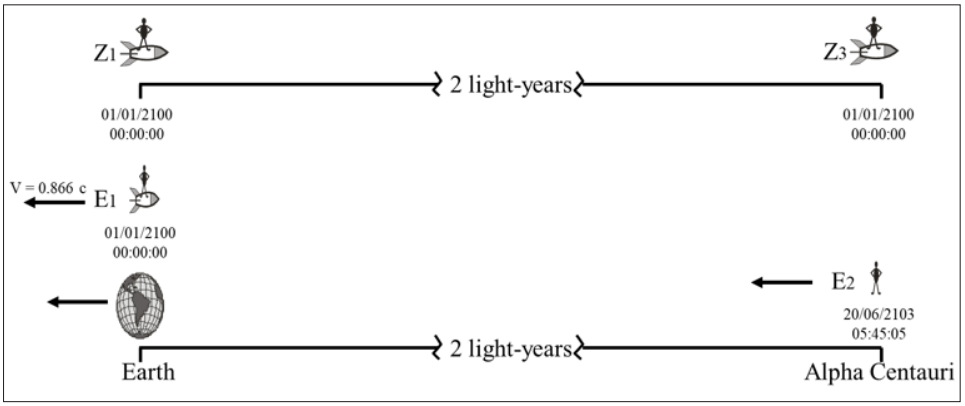

Figure 4: Start of the experiment as described from the **IS** of traveler **Z1**

References

1. Lorentz HA (1899) Simplified Theory of Electrical and Optical Phenomena in Moving Systems. KNAW Proceedings, Amsterdam pp: 427-442.
2. Poincaré H (1905) Sur la dynamique de l'électron. Comptes rendus de l'Académie des Sciences 140: 1504-1508.
3. Einstein A, Rosen N (1935) The Particle Problem in the General Theory of Relativity. Physical Review 48: 73.
4. Alcubierre M (1994) The warp drive: hyperfast travel within general relativity. Class Quant Grav 11: 73-77.
5. Einstein A (1905) Zur Elektrodynamik bewegter Körper. Annalen der Physik 17: 891-921.
6. Crotti M (2005) La Relatividad Conceptual. Ed. Imprenta Villagra Hnos. Available at: https://www.youtube.com/watch?v=gbPki8WNffI.
7. Torregrosa Lillo Angel (2024) Relatividad. Agujeros negros y Universo. ISBN: 979-8338228456 (2024). Available at: http://www.relatividad.org/.
8. Einstein A (1920) On Ether and Relativity. University of Leiden Lecture.