Resolution of the Half-Twin Paradox

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Abstract. This paper discusses the most notorious paradox of Special Relativity. The reciprocity of Lorentz transformation applied to a one way scenario is demonstrated on the first leg of the journey, however the only reason of reciprocity is that two systems use two different sets of events resulting naturally from relative simultaneity caused by Lorentz transformation. The actual problem which twin ages less cannot be resolved within the Special Relativity. The relative simultaneity seems to be only an artificial effect of clock synchronisation convention. If it was for real, it would cause violation of causality in some cases, which is demonstrated. There seems to be a possibility that the absolute simultaneity and preferred inertial reference frame are valid concepts, but the Special Relativity still has predictive power without the need of finding them if at all possible.

Keywords Absolute Simultaneity, Relative Simultaneity, Relativity of Time, Twin Paradox

Note: This is a draft version 0.1 published in a hope to trigger discussions and critical comments. The author would be grateful for any feedback that can be sent to:

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1 The Purpose and the Scope

Special Theory of Relativity (STR) appearing in Einstein's essay (1) postulates the validity of the principle of relativity of motion which states that physical laws are independent on the state of motion of the reference system at least if it is not accelerating. This on the surface implies an ideal symmetry. If a process occurring in system S is observed in a system S' then the same process occurring in S' should be observed in S in identical way. This conclusion has been challenged and the problem is known in the public domain by name of the Twin Paradox (TP) or as the Clock Paradox (CP). For the purpose of further discussion a succinct definition sourced from Wikipedia (2) has been chosen. It well represents this famous riddle described at length by multiple authors.

Def 1:

> *In physics, the twin paradox is a thought experiment in special relativity involving identical twins, one of whom makes a journey into space in a high-speed rocket and returns home to find that the twin who remained on Earth has aged more. This result appears puzzling because each twin sees the other twin as moving, and so, according to an incorrect naive application of time dilation and the principle of relativity, each should paradoxically find the other to have aged more slowly.*

It is worth mentioning that numerous sources define the paradox incorrectly pointing at differential aging as paradoxical thus evading the real issue of reciprocity. This goes as far as to high profile authors (e.g Hawking (3)).

In a draft article, A. Wutke (4) suggests that relative simultaneity is only an apparent effect of clock synchronisation not necessary the same as temporal coincidence. If this is justified, it should have an immediate implication in the explanation of the TP. The purpose of this study is the resolution of the simplified version of the paradox to the satisfaction of common temporal logic and consistent with laws of physics.

There is no intention to directly involve General Theory of Relativity (GTR) because the paradox has emerged in the context of the STR. It should be clear from this point of view whether or not GTR is indeed required. This can or/and has been done by experts in that field.

2 THE HALF-TWIN PARADOX

There is a lot of written material concerning the TP. Many relativity textbooks discuss or at least mention it, usually as a negative example of misunderstanding of sound scientific ideas. Students who learn relativity have to face it this way or another. Although not attracting much publicity these days, new publications are still coming to tackle this old riddle from modern perspectives. The current trend is to marginalise the paradox as a trivial misunderstanding annoyingly coming back in various discussions. One can see this in the presented definition 2 of the TP where the authors made an unreserved qualification as “naïve'' and ''incorrect'' at definition level before explaining why it might be the case.

There exists quite the opposite point of view according to which the TP is a significant controversy in physics of the twentieth’s century cf. Dingle (5). Despite many authoritative reassurances that the paradox does not exists, there is still some aura of uncertainty which was the main motivation of this paper.

The STR, despite the dramatic history of its conception and its final acceptance, is in fact a very simple theory proposing just two postulates and involving one coordinates transformation equation (as initially deduced by Lorentz from invariance of Maxwell equations). This was derived by Einstein using light constancy postulate and the principle of relativity together with a particular clock synchronisation scheme using light signals. What is more complex by many orders of magnitude are the consequences of this simple theory.

The STR involves two or more inertial systems (frames) moving at constant speed relative to each other. It does not directly describe how the multiple systems developed differences of velocity. This is similar to thermodynamics describing equilibrium states of matter and disregarding periods of transition from one state to another. As the first principle of thermodynamics postulates conservation of energy, it does not resolve in which direction the energy can be transferred between two subsystems in different states. For that we need the second principle. It appears similar relationship exists between the STR and the GTR.

2.1 Naïve Interpretation of the Relativity Principle

The incorrect and naive application of time dilation and the principle of relativity can be described in detail as follows:

Two initially sychronised coordinate systems at rest with embedded siblings separating such that one of them departs in the outer space. From the perspective of the stationary twin time dilation formula indicates that the travelling twin’s clock needs to run at lower rate. The easiest way to test this is to make the travelling twin to return and then to compare clocks. Inevitably one of them should be slower, so it should indicate smaller duration. The paradox is that the travelling twin can see himself at rest and apparently have the same expectations about the other. They cannot be both older and younger at the same moment upon reunion. So this is the paradox.

2.2 Paradox Resolution Attempts

The problem attracted a lot of attention from high profile physicists early in the 20th century and there is extensive literature available on this issue. We only highlight the most relevant points. A good overview by R. Shuler can be found in (6).

Because distant simultaneity in relativity presents a problem, than the easiest way to see the effects of time dilation is in the round trip scenario, when two clocks can be compared face to face. This immediately allows a formal rejection of the paradox which can be called a "legal argument". The legal argument is that the STR only describes the state of uniform motion while the round trip includes acceleration steady flight, turnaround and deceleration. This is enough to refute the paradox in the court of law based on technicalities, but it is not the argument a physicist should be particularly proud of.

The two uniform motion stages can be made arbitrarily long while acceleration periods are limited. For sufficiently long steady flight the possible acceleration effect may drop below experimental error and be completely neglected.

Most explanations do in depth analysis of all stages of the round trip, but prevailing view is that only GTR can resolve which out of the two inertial systems will have its clocks running slower (cf. Einstein (7) and Pauli (8))

Einstein in his landmark publication (1) had no concept of the GTR but he made the claim in this famous quote:

> *From this there ensues the following peculiar consequence. If at the points A and B of K there are stationary clocks which, viewed in the stationary system are synchronous; and if the clock at A is moved with the velocity v along the line AB to B, then on its arrival at B the two clocks no longer synchronize, but the clock moved from A to B lags behind the other which has remained at B by 1/2 tv2/c2 (up to magnitudes of fourth and higher order), t being the time occupied in the journey from A to B. It is at once apparent that this result still holds good if the clock moves from A to B in any polygonal line, and also when the points A and B coincide*

No calculations to prove the case are presented. Readers interested in the refutations of the TP may consult material contained and referred in (6).

The conclusion is that despite multiple attempts to explain the paradox, there are still new publication emerging to discuss the issue despite claims it has been solved. One of the reasons of failure to put the issue to rest is the complexity resulting from accelerations. This paper will eliminate this complexity without affecting the main problem: Which system ages less?

2.3 Differential Aging and Irreversibility of Clocks

It is necessary to notice that the final time difference in clocks "age" would accumulate incrementally along the path and not just at some discrete moments along the way. It is not clear why Einstein involves polygonal lines while explaining the "peculiarity" mentioned in the previous section. Any segment of the polygon can only be entered as a change in the velocity vector which is acceleration and would constitute a change of the inertial frame and thereby invalidating predicates of the STR. Change of inertial frames is frequently seen as the fundamental error of those who support that the TP is a real contradiction within the STR.

The minimum required to investigate the TP are two inertial observers equipped with four clocks.

Minguzzi (9) gives the following summary of differential aging:

The differential aging is the difference between the proper time of the clock at rest in the inertial frame and the proper time of the accelerating clock at the final meeting event. Special relativity predicts that the differential aging has always a positive sign independently of the arbitrary motion performed during the round-trip by the non-inertial observer.

The constraint at the final meeting point is a convenience assumption to suite the purpose of that author but by no means necessary[1] so is the notion of acceleration in which a zero value is also acceptable. In theoretical consideration proper time interval is defined as an integral: $\Delta\tau=\int_0^{t1}\sqrt{1-\frac{v_c(t)^2}{c^2}}\,dt$ where $v_c(t)$ is the velocity of the clock in a reference system, and there is no inherent constraint on t_1 other than being positive. It is wise however to define the physical condition to which t_1 applies and how the state of $\Delta\tau$ can be verified at t_1 to support experimental verification.

There is a reasonable expectation that proper time irreversibly "accumulates" in objects. For example Sommerfeld (9) p 94 is quoting Einstein's unproven assumption that clock in motion actually indicates its own proper time.

To be more precise, in the popular understanding the change of state of an object or a system said to occur "in time". Some objects/systems change the state irreversibly according to physical laws, notably in accordance with the second principle of thermodynamics. A mechanical or computerised clock which can only advance in one direction even when undergoing all kind of acceleration it will always advance one way. This is under assumption that in flat space time there is no conditions for time reversal (if that makes sense at all).

That is the reason why the accumulated proper time can be captured and stored as a permanent record in electronic or mechanical logs/graphs together with the identification of associated events that might be observed at clock's location. The conclusion is clock time cannot reverse and permanent record of it is physically possible after it stops.

We arrive at the following definition of differential aging in the context of the STR:

Def 2:

The differential aging is the detected difference between the proper time of the clock at rest in the inertial frame S and the proper time of the moving clock at S′ (stationary in S′) from the moment of synchronisation at t=t′=0 to an arbitrary moment t_1

$$\Delta\tau=\int_0^{t1}\sqrt{1-\frac{v^2}{c^2}}\,dt=t_1/\gamma$$

Where $\gamma=\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ and v is the constant speed of the moving clock in the absence of gravity fields.

[1] For example Pauli (13) refers to time dilation accumulating while traveling to a point P which may or may not coincide with the initial point.

Note: The location where t_1 is measured is relevant because the clock can be frozen and stopped there and information compared after communicating the result to an observer. In the above context clocks can only move forward and records of time can be made persistent.

2.4 Problem Statement.

The differential aging is the source of the twin paradox and usually involves proper time comparison after the completion of a round trip so the difference in age can be directly demonstrated. This however obscures and complicates the matter, as many authors (including Einstein (7)) claim initial and turnaround accelerations influence the outcome. The GTR is then necessary to come to rescue.

For the purpose of clarification, the initial focus is on the first stage of the round trip as described in the definition 1 of the twin paradox, which can be free of any accelerations in order to separate concerns.

This is called the Half-Twin Paradox (Half-TP). The point of view represented here is that once a clock is set in motion from rest it advances in its state being representative of time at a rate that is determined by laws of physics and it is monotonic and irreversible. When such clock is stopped by an event, it shows what the inertial system's time was when the stop event happened. The permanent record cannot be reverted.

The problems to be solved here are:

1. Is differential aging reciprocal? (i.e.) Does the twin paradox exist in the first leg of the journey?
2. Is differential aging supported by the STR alone when one object moves away from an established stationary reference and does not return?

2.5 Assumptions, Conventions and Constraints

1. The Special Theory of Relativity as described in (1) is correct such that it can describe physical states which could be realised in nature.
2. There exists a reference inertial system S referred as "stationary" with an established Cartesian coordinate system O, X,Y,Z where O is the origin at x=0,y=0 z=0.
3. There exists system S′ in inertial motion relative to S with velocity v along the X axis of S with X′axis of S′ aligned with X and Y ' and Z′ axes always parallel to Y, Z axes in S.
4. There exists clock A that is stationary in inertial frame S always at x=0 in S;
5. There exists clock A′ a moving with inertial frame S′ always at x′=0 in S′;
6. There exists clock B stationary in inertial frame S coinciding with clock A′ at x′=0
7. There exists clock B′ stationary in inertial frame S′ which coincides with clock A at x=0.
8. The above clocks and any other virtual clocks are deemed to be synchronised as per Einstein's light signal procedure. Virtual clocks represent time coordinate at any location within any of the possible inertial systems.
9. Any clock in motion actually indicates its own proper time.
10. Time at any point of space in any inertial system is a unique indication of a virtual clock situated there, constituting one and unique single valued event for the infinity of all possible inertial systems.
11. The S′ is accelerated prior to the experiment such that it arrives at synchronisation point x=0 at speed v so the appropriate clock rates are already established.

12. When referring to "origin" we assume the points (*ct, x=0,y=0,z=0*) or (*ct', x'=0,y'=0,z'=0*). This is because in real life the point or (*t=0, x=0,y=0,z=0*) exists only once at synchronisation due to irreversible nature of clock indications while (*x=0,y=0,z=0) (x'=0,y'=0,z'=0*) are physically detectable material points increasing distance within their respective rest frames.
13. When referring to "clock-simultaneous" we understand that clock-simultaneous events are those occurring in the same inertial frame at the same indication of two or more clocks, irrespective of the synchronisation method. The default method is the Einstein light signal method unless otherwise stated.

2.6 The Scenario

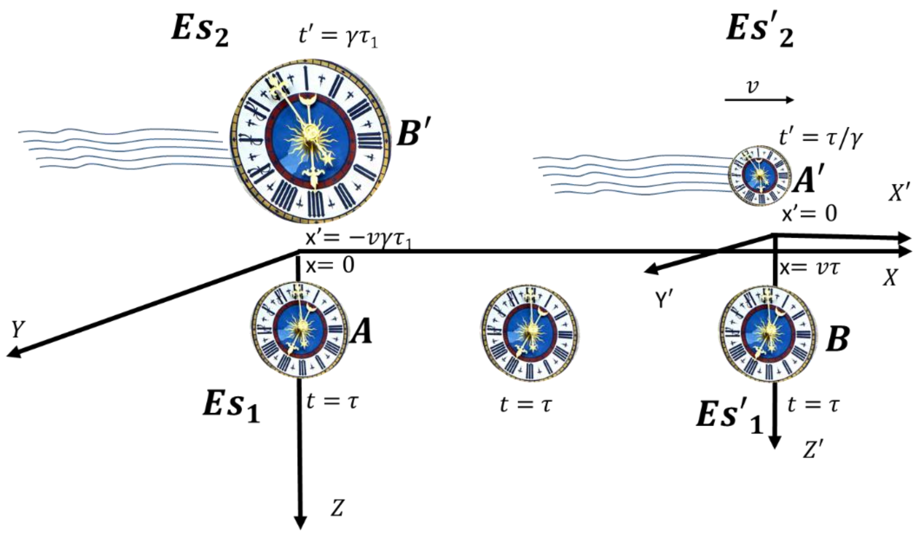

Figure 1 Half-Twin Paradox Scenario snapshot at time t=τ1.
The size of clock faces represent relative magnitudes of time coordinates at different locations in systems S and S1

This is a thought experiment but retaining a plausible physical context, although technical details could be overwhelming to accomplish it practically within a human lifetime and budget or achieve accuracy. To separate concerns we describe the scenario and build its mathematical model, then we make statements about the mathematical model parameters of the scenario referring to them as if they were real world parameters. The relationship between the real world and the mathematical model is presented in figure below partialy inspired by a presentation by A. Hajnal and I. Németi (11):

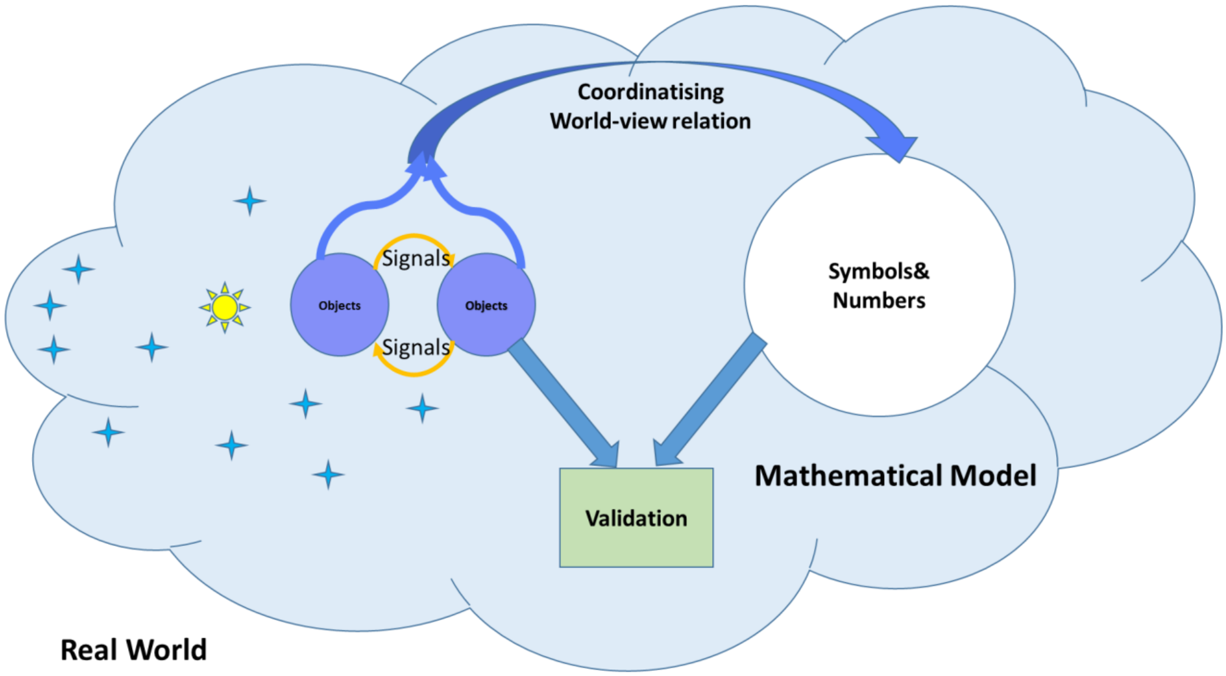

Figure 2Models and the Real World

In the analysis of the TP we consider two systems: one stationary S and one travelling S′, only during the receding leg of the journey. This is because in most cases round trip introduces complexities obscuring the real problem which still we believe exists within the first stage.

The initial acceleration is ignored by assuming the moving coordination system S′ is set in motion prior to synchronisation. The synchronisation is then triggered by physical coincidence of the origins of the two 3D inertial frames.

Whatever happens to the clock during the acceleration period is irrelevant, because after being left in the inertial motion phase, the clock rate is assumed stable.

Turn around is not taken into account as the moving system clock A′ is programmed to be stopped at a checkpoint established in S, using a device built within the clock B located at some distance in $L=v\tau_1$ in S, which will happen precisely at time τ_1.

Clock B also stops itself simultaneously with A′. Clock A at the origin of S stops itself at $t=\tau_1$ as well as it stops the coinciding clock B′ in S′.

This way accumulated proper times in clocks can be analysed post-mortem after the experiment without complication resulting from of changing inertial frames while trying to bring clocks A and B together as usually presented in numerous explanations of the paradox.

The important notion here is that all clocks are causally connected at common rest prior to the experiment and therefore they exist in the common temporal reality

2.6.1 Clock Events

The following events have to be considered in S and S′ inertial systems presented in the chronology relative to S:

1. The synchronisation event in S as Es_0which is re-setting clock A to t=0.
2. The synchronisation event Es'_0 $in\ S'$ when clocks A′ is re-set to t′=0. Both $Es_0 and\ Es'_0$are spatially and temporally coincident with each other indicating equal time t=t′=0.
3. An event Es_1 in S generated by clock B to trigger a stopping event for the timer on the moving clock A′ at the origin of S′ at some pre-defined time $\boldsymbol{t=\tau_1}$. That event also stops the timer on the clock B.
4. Event Es'_1 causally coupled with Es_1 raised in response to the Es_1, which causes freezing timer on clock A′. The events $Es'_1$and $Es_1$are spatially and temporally coincident despite time on their clocks being different.
5. An event Es_2 in in S that stops the timer on clock A at the origin of S precisely at the same pre-defined clock time τ_1, and it triggers the stop event on the timer on the moving clock B′ in S′ which is then coinciding with the origin of S.
6. Causally coupled event Es'_2 raised in response to the event Es_2 which is freezing timer on clock B′. The events Es'_2 and Es_2 are spatially and temporally coincident, despite time on their clocks being different.

The pairs of events $Es'_1,\ Es_1$ and $Es'_2,\ Es_2$ are temporally coincident (absolutely simultaneous) while , Es_1= Es_2 are clock-simultaneous if absolutes synchronisation is not possible.

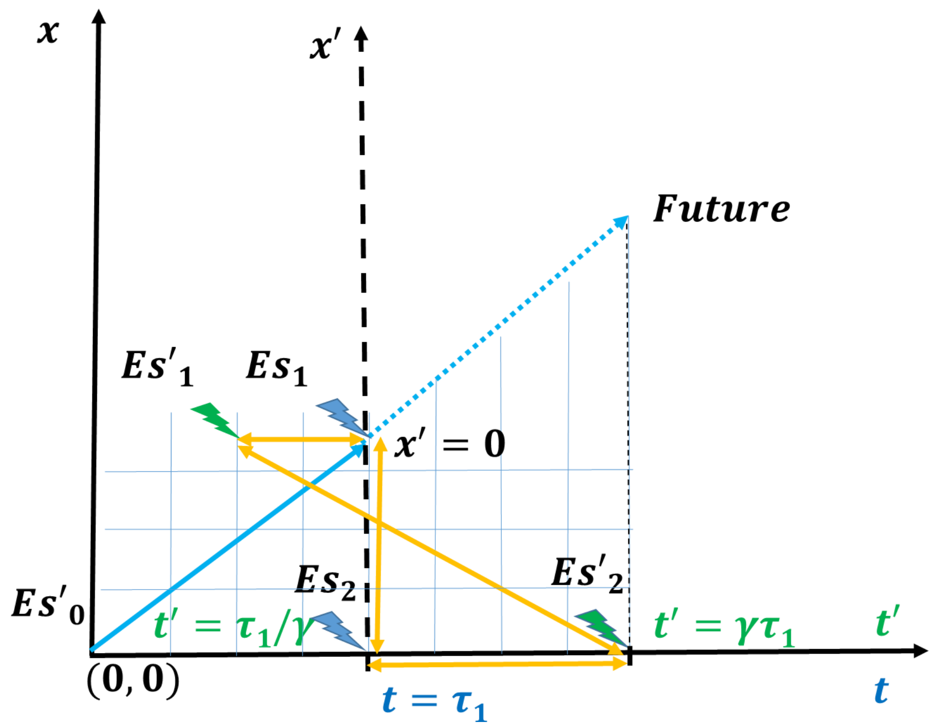

Figure 3 System S view of the Half TP scenario.

Primed system t′ axis superimposed on t at the same scale.

Synchronisation events in S and S′ are described as:

$$Es_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \; and \; Es'_0 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{1}$$

The arrival event of the moving System S′ terminated by S at time τ_1 as:

$$Es_1 = \begin{bmatrix} c\tau_1 \\ v\tau_1 \\ 0 \\ 0 \end{bmatrix} \tag{2}$$

The event Es_1 is triggering the stop event of the timer in S′ making a permanent record of those event at time $\boldsymbol{t}=\boldsymbol{\tau_1}$ indicated by clock B.

The arrival event in S′ causally coupled to $Es_1$is:

$$Es'_1 = \boldsymbol{L} \begin{bmatrix} c\tau_1 \\ v\tau_1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} c\tau_1/\gamma \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{3}$$

Where $\boldsymbol{L}$ is the Lorentz Transformation matrix:

$$\boldsymbol{L} = \begin{bmatrix} \gamma & \frac{-v\gamma}{c} & 0 & 0 \\ \frac{-v\gamma}{c} & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{4}$$

Observation 1

At $\boldsymbol{S'}$ origin, clock B indication is then t′=τ_1/γ and compatible with the proper time formula for this clock. Since $\gamma > 0$ we conclude that in S′, clock B indication is lower than τ_1 upon arrival at the checkpoint. Therefore the clock B in S′ seems to be progressing at relatively slower rate than the clock A. This is of course what it has always been said about moving clocks since year 1905.

An event at the origin of S, clock-simultaneous with the S′ arrival event at the checkpoint in S is:

$$Es_2 = \begin{bmatrix} c\tau_1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{5}$$

The event Es_2 as transformed to S′ is:

$$Es'_2 = \boldsymbol{L}Es_2 = \begin{bmatrix} \gamma c\tau_1 \\ -\gamma v\tau_1 \\ 0 \\ 0 \end{bmatrix}$$

(6)

2.1 The Solution

The Half-TP problem can be solved by analysing selected clock events for clocks A, B, A′, B′ within the standard framework of the STR.

Observation 2

The time on the moving clock B′ in S′ coinciding with the origin of S which has the proper time $t = \tau_1$, is t′=$\tau_1 \gamma$. It does not apparently agree with the proper time formula unless the lower integral bound is less than 0 which is relative past with respect to synchronisation moment. Since $\gamma > 0$ we conclude that this clock indication belonging to S′ coinciding with the clock A is higher than τ_1 giving the impression that clock B might have run at higher rate contrary to the well-known rule that moving clocks run slower. The reality of this time relation cannot be questioned because the clocks are in direct contact at that moment. The time on clock B′ is also much greater than that of the event Es'_1 on clock A′ at the origin of S′ which is equal to τ_1/γ there upon arrival at the checkpoint. This is customary attributed to relativity of simultaneity. The time of the event Es'_2 is somewhat in the future of the event Es'_1. It would be hard to believe it has anything to do with the real future since all clocks in the scenario were causally connected before the experiment has started.

Admitting that Clock B′ has moved from the present to the future as a result of accelerating to velocity v is more of a science fiction interpretation.

We have to rule out different clock rates in one and the same inertial system. The only available explanation of the higher time indication is that moving clock B′ higher time figure while coinciding with clock A is the synchronization time offset (phase) effect that is different for every clock depending on its position relative to master clock A′ as can be seen from Lorentz transformations.

That is an additional confirmation of the conventional nature of relative simultaneity as prompted by publications of Kantor (12), Jackson and Pargetter (13) and Wutke (4).

Event Es'_2 in the sense of clock-simultaneity does not appear simultaneous with the arrival event Es'_1 in S′. Upon arrival to the checkpoint, the system clock A′ time in S′ t′=τ_1/γ and can be permanently recorded in S′ and similarly in the coincident clock B in S as τ_1. Empirical verification of the two records is then possible post-mortem after information exchange by radio about clocks states when they are finally stopped.

Observation 3

If the Special Relativity is correct then in this scenario there is no option other than the S′ clock A′ has to slow down during the departure stage of the journey on the moving system S. Only relative speed v and speed of light c are used in calculations, there is only one Lorentz transformation equation for each event, and there is no visible or hidden assumption which system S or S′ is the one that has moved from the common rest state. This becomes the main issue in the TP.

In order to verify the Half-TP, the same scenario needs to be re-interpreted from the point of view of the system S'.

The synchronisation event is common in either interpretation.

The pseudo "arrival" event of the system S within S′ axes taken as stationary can be formally defined as:

$$Es'_3 = \begin{bmatrix} c\tau_3 \\ -v\tau_3 \\ 0 \\ 0 \end{bmatrix},$$

(7)

where τ_3 is some arbitrary duration yet to be determined. From there we can calculate the event description in S coordinates by using inverse Lorentz transformation.

$$Es_3 = \boldsymbol{L}^{-1} Es'_3 = \begin{bmatrix} c\tau_3/\gamma \\ 0 \\ 0 \\ 0 \end{bmatrix},$$

(8)

If the experiment is to reflect the reality already established from the point of view of S, then $Es_3 = Es_2$, therefore:

$$Es_3 = Es_2 = \begin{bmatrix} c\tau_3/\gamma \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} c\tau_1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

(9)

From that we have: $\tau_3 = \gamma\tau_1$. This implies:

$$Es'_3 = Es'_2 = \begin{bmatrix} c\gamma\tau_1 \\ -v\gamma\tau_1 \\ 0 \\ 0 \end{bmatrix}$$

(10)

2.2 Determining Reciprocity

It appears that the time on the clock A′ t′= τ_1/γ of the arrival event Es'_1 of the system S′ at the checkpoint, is not the same as that of the apparent "arrival" event Es'_2 of the partner system S as appears on clock B′.

The time is t′=$\gamma\tau_1$, by appearance is somewhat in the future of the event Es'_1.

But the observer near the clock A′ has no idea about time $t = \gamma\tau_1$. All he has is his own measured time that happened to have the value of τ_1/γ.

To determine corresponding clock time event in S, the moving observer seeing himself as stationary would naturally use the same approach as the observer in S. He would define the event Es'_4 clock-simultaneous with his system clock A′ at the other system expected relative position which would naturally appear as $-v\tau_1/\gamma$ if the same coordinate system was used:

$$Es'_4 = \begin{bmatrix} c\tau_1/\gamma \\ -v\tau_1/\gamma \\ 0 \\ 0 \end{bmatrix} \qquad (11)$$

It is then natural to apply Lorentz transformation to the event Es'_4 which is clock-simultaneous with Es'_1.

In this case we have:

$$Es_4 = \boldsymbol{L^{-1}} Es'_4 = \begin{bmatrix} c\tau_1/\gamma^2 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad (12)$$

This defines a possible event in S but the one which never happened in the discussed scenario.

Although clock A must have passed $t = \tau_1/\gamma^2$ to reach τ_1 there was no clock stop event programmed.

3 DISCUSSION

The time relations within the pairs of events:

Es'_1 and Es_2 and analogous Es_4 and Es'_1

are all valid however Es_4 and Es'_1 are not representing the same moment in history of the system S that decides on simultaneity of arrival events, so there is no contradiction in that the rate of the clock A appears relatively lower.

The real question is whether the clock in S' has indeed indicated $c\tau_1/\gamma$ at the checkpoint. That could only be verified experimentally and only one clock can be slower. Should A' clock was found faster, then we would have to conclude we had picked the wrong system as the stationary one.

So far we have come to a conclusion that the proper time accumulating in clocks whether travelling or not, is irreversible under usual conditions of inertial systems so it is of an absolute nature. We have determined that time dilation formula in the form:

$$\tau_{moving} = \frac{\tau_{stationary}}{\gamma}$$

seems to be reciprocal but the reciprocity does not result from the comparison of the same events by the very nature of the scenario. One has to make an assumption which system is the reference for clock simultaneity of the two origins coinciding with pre-defined checkpoints.

We made a remark in Observation 2 that after synchronisation, the time of the event Es'_2 is somewhat in the future of the event Es'_1 while the two clocks have lived in common frame and were causally connected by manufacturing them for the experiment. The arbitrariness of the concept of relative simultaneity resulting from Einstein clock synchronisation is clear, yet it does not mean it is erroneous to use Lorentz transformation for events associated with clocks correspondingly synchronised.

Admitting that Clock B' has moved from the present to the future as a result of accelerating to velocity v is more of a science fiction interpretation. It is more practical to see time trough clocks only bearing in mind that any experiment with clocks requires them to be manufactured beforehand and prior to their synchronisation. This can provide the necessary reality check.

It can be said in the form of a conjecture that the reality of absolute simultaneity and preferred reference frame seems to be linked to the positive verification of the full twin paradox: If the travelling twin indeed returns younger then there should be a preferred inertial frame and absolute simultaneity within it. It is possible however it may never be determined with an adequate accuracy.

4 Conclusions

In the view of the presented material I conclude that:

1. The Half-Twin paradox can be discussed without complications added by acceleration and turn around problems, assuming that the relatively moving system's clock is stopped at a pre-defined checkpoint relative to the stationary system. The results can be communicated after the experiment and compared.
2. In the framework of the STR, the application of the same computation and experimental procedure by each twin for the same one way departure, will produce reciprocal results (i.e. no real paradox) by which the other twin's clock appears to run slower. The problem is that the calculation is done not against the same physical events. This is because each system determines partner's arrival at the checkpoint differently based on its clock-simultaneity which is not necessarily equivalent to temporal coincidence.
3. STR does not determine which out of the two twins should age less, but it does not limit its predictive power.
4. Einstein clock synchronisation procedure in conjunction with Lorentz transformation allow causally connected clock to travel to one system's future. This highlights artificial nature of the relative simultaneity.
5. There is no temporal/logical paradox to see two remote clocks in the same inertial frame having two different values while being temporally coincident. Any arbitrary synchronisation rule for distant clocks can demonstrate this.
6. This by no means limit the predictive value of the Special Theory of Relativity which is consistent with its clock synchronisation method and the nature of synchronised clock indication is understood.

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