The “triplet paradox” overthrows the “twin paradox”

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Microarticle

The “triplet paradox” overthrows the “twin paradox”

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A R T I C L E I N F O

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A B S T R A C T

The twin paradox will be explained using the triplet paradox. After returning from the journey, the travelling triplet cannot be younger than one and older than the other triplet, when the latter two rest at the two ends of the travelling triplet’s road!

Introduction

When twin A travells on a return trip relative to twin B who rests, why can’t twin A considers himself in rest and twin B as a traveller? An explanation for this was given by Langevin in 1911 [1], and then the same is repeated until today [2–5], known as the twin paradox. In 1982, the triplet paradox [6] was proposed, but in it, the triplets work like the twins. In this short paper, we will ask triplets to behave in that way, which will argue that Langevin’s trick [1–6] cannot be taken as a scientific answer. Explaining the twin paradox requires a thought experiment. On the other side, using the triplet paradox, the experiment is quite real and these things are enough: a conveyor belt, balls, three watches, and three stopwatches.

Triplet paradox vs. twin paradox

To explain the twin paradox claim, that the travelling twin becomes younger than the stay-at-home twin, six stages of triplets’ behaviours will be presented (Fig. 1).

In the first stage, we see the triplets together, which are resting (Fig. 1.1). In this point, their watches show the same time. Now the triplets move so that the triplet sister with one triplet brother moves left, and the other triplet brother moves right. They all move at the same speed and stop after crossing $5m$ of the road.

In the second stage, we see triplets resting $10m$ apart, two of them together and one alone. Their watches still show the same time because, to be sure of that, they moved at the same speed from the moment they separated and stopped at the same distance from the point of separation (Fig. 1.2). The triplet sister let throw periodically ten balls toward the right triplet. The balls’ speed is the same ($u' = 2m/s$), and their period is $1s$. The left-resting triplets start the stopwatch, and both confirm that balls are thrown within 10 s. While the triplet on the right starts the stopwatch when he receives the first ball. This triplet also receives these 10 balls, within 10 s. Let’s use this notation: n is the number of thrown/received balls; f is the frequency of received balls by the left-resting triplet, t is the time interval within which this triplet receives the balls; f'' is the frequency of received balls by the right-resting triplet, t'' is the time interval within which this triplet receives the balls; f' is the frequency of the throwing balls, t' is the time interval within which the triplet sister throws the balls; then, this equation holds,

$$n = ft = f't' = f''t''. \tag{1}$$

At the very beginning, it is worth noting that this equation is valid for both Galilean and Einsteinian relativity [7]. So, the fact that there is no Lorentz factor in Eq. (1) shows that the causes of relative frequency (f and f'') and relative time (t and t'') can be different, but these causes do not change the standard of time measurement. In the second stage (Fig. 1.2) we see that all frequencies are equal ($f = f' = f''$), and all time intervals are equal too ($t = t' = t''$), however time’s intervals t and t' begin from the throwing of the first ball, while the time interval t'' begins 10 s later. For this reason, we use watches and stopwatches.

In the third stage, the triplet sister by means of a conveyor belt moves at constant speed $v = 1m/s$, toward the right-resting triplet, and throws balls with the same speed and same frequency (f'), toward both brothers (Fig. 1.3). Eq. (1) is valid for this stage too, but now frequencies and time intervals are not equal. The triplet sister starts the stopwatch when she throws the first balls, while the triplet brothers start their stopwatches when receiving the first ball. This means, the left-resting triplet starts his stopwatch prior to the right-resting triplet. In fact, the left-resting triplet catches the first ball very prior to the right-resting triplet, but he catches other balls very rarely (frequency f); on another side, the right-resting triplet catches the first ball very late, but he catches other balls more oft (frequency f''). This means that the time intervals t and t'', which

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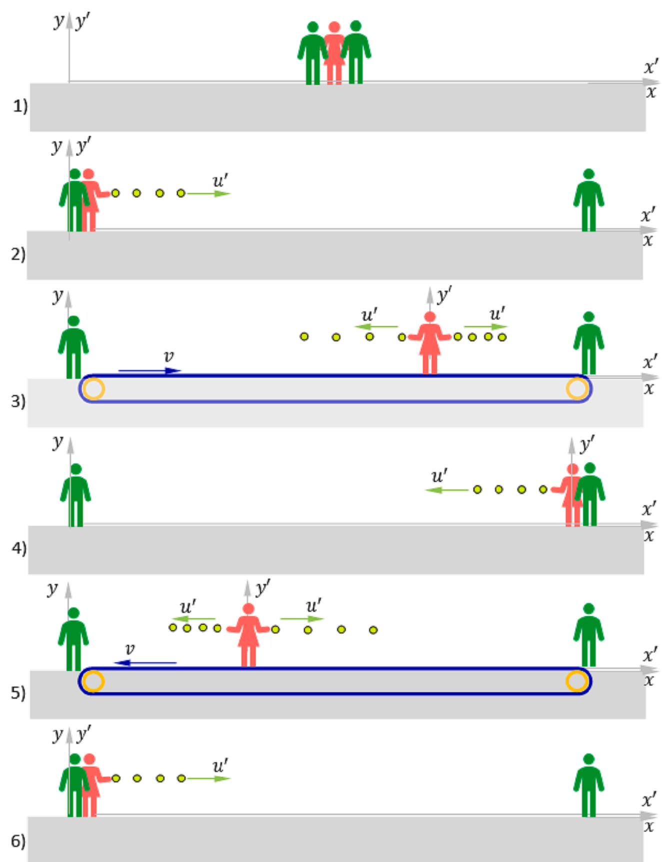

Fig. 1. Triplet paradox.

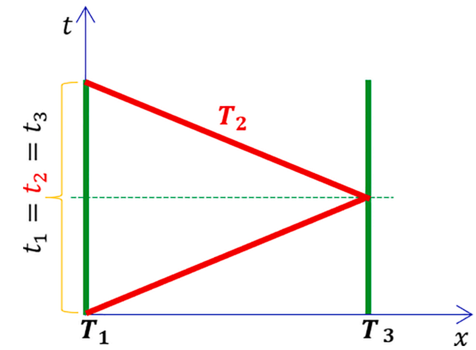

Fig. 2. Space-time diagram of "triplet paradox".

show their stopwatches, differ, and they stay so that Eq. (1) must be valid. As for their watches, since they are resting, there is no reason to have changed their behaviour; therefore, their watches show the same time. Now let's focus on the watch, frequency, and stopwatch of the triplet sister. First, the triplet sister's watch, and stopwatch work equally; second, the frequency f' is $1Hz$, which means that the triplet sister throws 1 ball per second, until throws $n = 10$ balls. Third, since the frequency f' is $1Hz$, for Eq. (1) to be valid, the time interval shown by the stopwatch must show $t' = 10s$. From these three facts, the conclusion is drawn that the triplet sister watch has not changed its behaviour relative to watches of the two other triplets; and that the heart of the triplet sister (represented here by thrown balls) beats at the same rate during the three phases of this event, so not as D. Griffiths claims [4].

In the fourth stage, we have the same situation as the second stage. The triplet sister arrived to the right-resting triplet and by throwing the ten balls with the frequency $1Hz$, toward the left-resting triplet, confirms that Eq. (1) is valid, and all frequencies are equal, as well as all time intervals.

In the fifth stage, we have the analogue situation as the third stage, with the only difference that now the frequency f'' is smaller than the frequencies f and f', and the time interval t'' is longer than the intervals t and t'.

In the sixth stage, we have the quite same situation as the second stage, which completes the turn trip of the triplet sister.

Discussion and conclusions

The first important conclusion of this paper is this: the time intervals within which the balls are thrown and caught are the time intervals of this case. Events such as throwing and catching balls cannot affect the order of other events in the universal time axis. The universal time axis is adjusted by agreement, by means of another reference event, which is unrelated to the events under consideration; therefore, the timing of this axis cannot be influenced by what happens to the event under consideration. Time intervals of throwing and receiving the balls are read on their stopwatches. Only the possibility of reflecting the time intervals of the events under consideration (t, t' and t'') on the universal time axis gives meaning to their measurement.

Since the third and fifth phase shows that there is no change of work in the triplet's watches, then there is no place for the trick explained by the "*system experiencing acceleration*" [1–6]. Let's assume that the work of the triplet sister's watch, relative to the brother triplets' watches, changes. Then, where do we read this change? In watches, or in stopwatches? According to the proponents of the twin paradox, this difference is read in stopwatches [8]. Then, according to this paper, the twin paradox is impossible due to these two reasons: first, the difference between time intervals measured by stopwatches is very large (in the third stage, $t = 13.33s$, $t' = 10s$, and $t'' = 6.66s$). If the difference were so great, for a motion with such small speeds, then there would be no sense in measuring time. Even STR does not preach such a great difference as time dilation. Second, there is no way that at the same instant time, the triplet sister to be younger than one and older than the other triplet brother, when both triplet brothers are resting in the same system of reference. The "*system experiencing acceleration*" trick cannot be applied to these two triplet brothers because the conditions of this trick are not met the same for both. Indeed, even in its essence, the "system experiencing acceleration" does not fully respect the symmetry of the two twins [9].

The standard unit for measuring time is determined by agreement in certain circumstances and with certain reference event. In other events that we encounter, the motion of the systems causes a difference between the observed and emitted frequencies (Doppler effect), and this difference is observed (measured) by means of the standard unit; but this change cannot change the standard unit.

Finally, "triplet paradox" can be represented by space–time diagram (Fig. 2), which shows that there is no change between triplet watches. Two green lines (vertical lines) and red lines (oblique lines) represent graphs of the triplets' motion, while comparison of their covered distances and time must be read in abscissa and ordinate ($t_1 = t_2 = t_3$).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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