Comment on "Has the Twin Paradox Really Been Resolved?"

Rodrigo de Abreu
Departamento de Física, Instituto Superior Técnico
Universidade de Lisboa, 1049-001 Lisboa, Portugal

In a recent paper [1] about the Twin Paradox conundrum the authors state that "*perhaps the most perplexing and controversial thought experiment in physics, and particularly in the theory of special relativity, is the twin paradox, which was realized by Einstein himself in 1905. The description of this paradox can be found in many places in the literature [1] - [8].*

The paradox is based on the concept of time dilation in the theory of special relativity. If observer O' moves with velocity v relative to observer O, then the time interval between two events taking place at the same point in the frame of reference of the moving observer Δt' (known as the proper time) is related to the same time Δt measured by observer O according to [1] [2] [3] [9]".

Within the present formulation of special relativity, a "non-paradoxical" interpretation of the asymmetric ageing of the twins emerges. It is based exclusively on the rhythms of the clocks, which are not related by the standard textbook expressions ("time dilation") and shall not be confused with clock time readings.

The paradox emerge as a result of the confusion in the identification of the proper times [1-10] with the time dilation mathematical expression.

There are many explanations of twin paradoxes that contradict each other.

From the presentation of the broader view of special relativity proposed [3-8], in particular with the distinction between clock rhythms and clock time readings, together with the indeterminacy of special relativity [5, 9], which does not allow to know in which inertial frame clocks are actually running slower, the meaningful solution to the paradox is already clear. The symmetry in the description of the outward trip between Andrew and Bob when we refer to Lorentzian times, repeated also for the return trip, does not correspond to a symmetry in the ageing (proper times) of the twins. Regarding proper times, we know that during the outward trip either Andrew or Bob is ageing slower and, without a reference to the rest system, we do not know which of them. And it may even happen that both are ageing at the same rhythm. The same occurs during the return trip. It is possible that it is always one of the twins who is ageing slower, both on the onward and on the return trip, or that one of the twins ages slower during the onward trip and the other during the return trip, or even that in one of the trips they are ageing at the same rate. However, we do know that when they meet it is Bob who is younger, and by which factor. Of course, that all calculations can be made both with Lorentzian times and with synchronized times and from the point of view of each of the twins: all these calculations must give the same final result.

A straightforward analysis made with proper times and the IST transformation removes all difficulties surrounding the paradox at the onset. In particular, it is no longer said that each twin sees the other ageing slower during the length of the one-way trips. Instead, both twins agree that in each part of the trip one of them is ageing slower while the other is ageing faster (or are both ageing at the same rhythm). The simple addition of the proper times of the onward and back trips then directly gives the final result for both twins. There is no need to correct for any strangeness on the turnaround period nor for any supposed effect of acceleration and equivalent gravitational fields. Specifically, there is no need to add any factor to Andrew's age due to a change in inertial frame of Bob, whatever point of view is considered.

In previous papers we have proposed a general formulation of special relativity, where the postulates are formulated in a weaker form than in the traditional presentation, while keeping fully compatible with all experimental evidence [3]. The theory assumes the existence of (at least) one reference frame where the one-way speed of light in vacuum is isotropic and equal to c, denoted as the preferred frame [2, 3]. It was shown that the theory is undetermined, unless the one-way speed of light in one reference frame is measured. The somewhat evident but very important difference between "time readings of Lorentzian clocks" and proper times or clock rhythms is thoroughly discussed. It is noted that although the description of time dilation made with Lorentzian clocks is symmetrical for two inertial observers in relative motion, as it is well-known from the standard interpretation of special relativity, the reciprocal relation does not relate the clock rhythms. Actually, the time dilation relation between the clock rhythms of two inertial observers in relative motion is not symmetric. During each one-way trip one of the observers is actually ageing slower than the other, or it may even happen that both are ageing at the same rhythm. Furthermore, without reference to the rest system it is impossible to know which of them is actually ageing slower, in another way of stating the indeterminacy of special relativity. Within this context, in this work we have discussed the twin paradox in detail, as an illustration of the power and simplicity of the general formulation of special relativity formerly presented. In a round-trip such as the one in the classical configuration of the twin paradox, it is the returning twin who is younger when both twin meets, despite the impossibility of knowing which of the twins is younger at each phase of the trip. The result is due to the cumulative effect of the clock rhythms along the complete journey. The total ageing of each twin is calculated directly from the sum of their proper times on the onward and the return trips. Contrary to what happens in the standard interpretation of special relativity and of general relativity, there is no need to consider any additional ageing factor of the resting twin as seen by the moving twin to account for the change in reference frame or the acceleration. As a matter of fact, the factor invoked by these standard interpretations was deduced from the offset between Lorentzian and synchronized clocks. It was thus demonstrated that this factor has nothing to do with any modification with the clock rhythms and with the ageing of the twins during the turn-around period. It is merely a correction to a peculiar way of giving the initial adjustment (a so-called "synchronization") to the clocks. Therefore, it becomes clear that acceleration does not play any role in the twin paradox other than telling which of the twins is returning back. Finally, we would like to underline the following. The standard interpretation of special relativity pretends to assign a physical meaning of real ageing to assertions like "during the onward trip Bob sees Andrew ageing slower, Andrew himself also sees Bob ageing slower, but the change in inertial frames corrects this symmetry, as a result of the relativity of simultaneity, and makes it in the end that Bob is younger when the twins meet." The standard interpretation of general relativity pretends to assign a physical meaning to sentences like "during the turnaround period Bob sees Andrew ageing very quickly because he sees him under the effect of a gravitational field at a higher gravitational potential." These are erroneous interpretations of correct mathematical results. One message we want to convey regarding the twin paradox is that such discourse is no longer tolerable and should become "unspeakable:" it was proven that "seeing the other twin ageing slower" is meaningless in this context and corresponds to the symmetric description arising from the comparison of the time readings of Lorentzian clocks, whose roots lie in the indeterminacy of special relativity. It does not correspond to the clock rhythms and to the ageing of the twins.

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