Why is the theory of special relativity contradictory?

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The purpose of this note is to explain the contradiction inherent in the special theory of relativity and to set out the reasons for it.

Since the death of Herbert Dingle (1890–1978)[1] , the debate on this point seems to have died down. The new contribution we offer consists of an alternative approach to relativity that explains the experimental results without introducing time dilation between reference frames in relative motion – thereby resolving the contradiction.

Further details can be found in the notes referred to in the footnotes. These notes are published on the website: [https://www.aimer-la-physique.com/].

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1. Galilean reference frames

Galilean reference frames are those in which space appears homogeneous and isotropic and time appears uniform with respect to physical phenomena, meaning that these phenomena remain unchanged by translations in space, rotations in space and time translations.

The very definition of Galilean reference frames dictates that two Galilean reference frames in relative motion are necessarily in uniform, rectilinear spatial translation relative to one another.

Galilean reference frames are associated with a very important property, which constitutes the **principle of relativity**:

'The laws of physics remain invariant under a change of Galilean reference frame'.

Reference frames comprise :

- on the one hand, a coordinate system providing spatial coordinates by means of graduations based on a standard of length;
- on the other hand, clocks[2] placed at every point on the coordinate system, each providing a unit of time identical to that of a standard clock.

The units of spatial distance and duration are, of course, identical in all reference frames.

[1] Herbert Dingle*, *Science at the Crossroads**, 1972, reprinted by GogLib.

[2] A clock is a physical device that measures time through a succession of identical cycles.

The **synchronisation of the clocks**[3] within the same reference frame makes it possible to measure the duration between two events occurring at two different points; two events are said to be simultaneous if they occur at the same instant as indicated by the clocks situated at those points.

Let us consider two Galilean reference frames in relative motion. If, at a given instant t in one reference frame, all clocks in the other reference frame show the same time t' (which can therefore be made equal to t by a global time shift), time is considered to be absolute.

The equations relating the spatial and temporal coordinates of the same event in two Galilean reference frames are then the (so-called Galilean) equations of Newtonian mechanics. The law of addition of velocities associated with these equations imposes no limit on the velocity of a moving body.

2. Special Theory of Relativity

The special theory of relativity leads to the rejection of the notion of absolute time: clocks appear to be out of sync from one reference frame to another.[4]

Without prejudging the content of the theory, we may take this assertion as a hypothesis in order to establish the coordinate transformation equations that allow us to move from a Galilean reference frame Σ (x, y, z, t) to a Galilean reference frame Σ' (x', y', z', t') moving in a straight line at a constant velocity relative to Σ, parallel to the (x)-axis. [5]

We set: $t = t' = 0$ when the origins of the reference frames coincide; we denote by u the velocity of Σ' relative to Σ.

The invariances associated with the concept of a Galilean reference frame require that the coordinates transformation equations be linear.

We begin by showing that desynchronisation is linked to the existence of a limiting velocity (which turns out to be the free-space speed of propagation c of electromagnetic waves in a vacuum).

It follows that the law of composition of velocities along the (x)-axis (v in Σ and v' in Σ') is given by:

$$v' = (v - u) \,/\, (1 - uv/\mathbf{c}^2) \tag{1}$$

The equations for converting from coordinates in Σ to coordinates in Σ' are given by:

$$\begin{cases} x' = a\,(x - ut) \\ t' = a\,(t - u\,\mathbf{x}/\mathbf{c}^2) \end{cases} \tag{2}$$

The inverse equations are:

$$\begin{cases} x = a'\,(x' + u\,t') \\ t = a'\,(t' + u\,\mathbf{x'}/\mathbf{c}^2\,) \end{cases} \tag{3}$$

[3] See the note *'Another Approach to Relativity',* paragraph 2.2.

[4] In the note *'Mass, Energy and Reference* Frames', it is explained that the desynchronisation of clocks can be seen as a consequence of **Mach's Principle:** ***the inertia of material objects is induced by the sum of all other masses present in the universe.***

[5] See the note *'Another approach to relativity',* paragraphs 2.3.1. to 2.3.3.

where: $$a\,a' = \Upsilon^2 = 1/(1-u^2/c^2) \quad (4)$$

When the clock in the Σ reference frame, situated at the point with coordinate x, reads t, this means that the time elapsed since the origin of time in Σ is equal to t.

The clock in Σ', situated opposite it at abscissa x', shows a time t' given by equation (2), which can also be written as:

$$t' = a\,(1-u^2/c^2)\,t - u\,x'/c^2 = (a/\Upsilon^2)\,t - u\,x'/c^2 \quad (5)$$

However, observers in Σ note that at time 0 in Σ, the clocks in Σ' show times other than 0 (desynchronisation). Thus, applying relation (5), the clock situated at x' shows a time:

$$t'_0 = -u\,x'/c^2$$

For the observer at x in Σ, the elapsed time in the Σ' reference frame is therefore equal to:

$$t' - t'_0 = (a/\Upsilon^2)\,t$$

It should be noted that the above relationship does not depend on x and is therefore valid regardless of the observer. For observers in Σ, if a time interval Δt has elapsed in their reference frame, it appears that the following time interval has elapsed in Σ':

$$\Delta t' = (a/\Upsilon^2)\,\Delta t \quad (6)$$

Depending on the value assigned to the parameter a, a discrepancy may therefore arise between the times elapsed in the two reference frames. It should be noted that Δt' is measured using the same clock, whilst Δt results from measurements made by two separate clocks.[6]

Second major assumption: the theory of relativity postulates that it is impossible to distinguish between Galilean reference frames.[7]

When writing the coordinate transformation equations (2) and (3), we therefore choose:

$$a = a' = \Upsilon \qquad \left(= 1/\sqrt{1-\frac{u^2}{c^2}}\right)$$

The coordinate transformation equations and their inverses then have exactly the same form. **This yields the Lorentz equations:**

To transform from (x, t) to (x', t'):
$$\begin{cases} x' = \Upsilon\,(x - ut) \\ t' = \Upsilon\,(t - u\,x/c^2) \end{cases} \quad (7)$$

To go from (x', t') to (x, t):
$$\begin{cases} x = \Upsilon\,(x' + u\,t') \\ t = \Upsilon\,(t' + u\,x'/c^2) \end{cases} \quad (8)$$

Note that this choice leads to total invariance of the speed of light, regardless of the direction of the light rays under consideration.

[6] At time 0, the reading in Σ is that of the clock corresponding to x'.
[7] This postulate goes beyond the principle of relativity.

Equation (6) becomes: $\Delta t' = \Delta t / \Upsilon$ (9)

We observe a time dilation between two events, measured using two different clocks (in Σ)[8] relative to the duration measured by a single clock (proper time), that is, in the reference frame where these events have the same spatial position (Σ').

3. An inherent contradiction in the theory

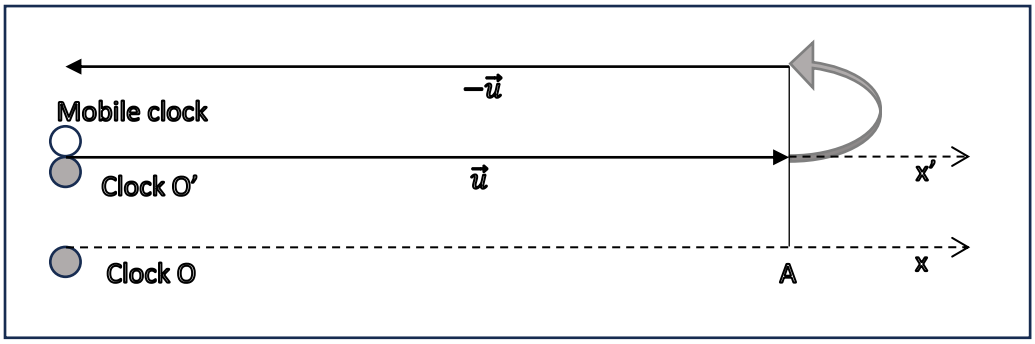
In light of the above, the following question arises: Does time dilation have a physical reality, or is it an apparent effect linked to the desynchronisation of the clocks?

3.1. *Is it possible to devise an experiment that would allow us to compare the durations recorded by a clock at Σ and a clock at Σ' whilst avoiding the phenomenon of desynchronisation?* [9]

Note that the clocks situated at the common origin (O, O') of the reference frames do not exhibit any desynchronisation at time 0, since we have chosen to synchronise them at this point.

The experiment we propose involves transporting a clock from Σ at speed u so that it is brought alongside the clock O' of Σ' at time 0, synchronising it at that instant. This clock then travels back and forth along the (x)-axis, at speed u on the outward journey and at speed -u on the return journey. It therefore remains in contact with the clock O' at Σ' throughout the outward journey.

On its return to O, the time displayed by the moving clock is compared with that given by clock O at Σ, which has remained stationary. The duration of the straight-line journeys is assumed to be sufficiently long that the time taken for the U-turn and the final deceleration can be neglected in the comparison.



Let us now highlight an important assumption accepted by the theory of special relativity: during rectilinear motion at constant speed, the rate of a clock is not affected by its motion, nor by any periods of acceleration or deceleration it may have undergone previously. This means that it measures the same unit of time as the clocks in the reference frames.[10]

[8] At time 0, the measurement in Σ is made by the clock corresponding to x'.
[9] See the note *'Another approach to relativity',* paragraph 2.3.4.
[10] In Part 4, we shall see that this assumption is not retained in the new approach to relativity.

During the outward journey OA, the moving clock therefore records the same time as the clock O'.

In light of what was discussed in Part 2 of this note, applying the theory of special relativity leads to the prediction that, at the end of the outward journey, the moving clock will indicate a shorter journey time than clock A in Σ, which is facing it:

$$t' = t/\gamma\ .$$

By symmetry, the durations of the return journey are identical to those of the outward journey: in Σ, the duration of the AO journey at speed $-u$ is equal to that of the OA journey at speed u. And we may consider attaching to the moving clock a reference frame Σ'' moving at speed $-u$ relative to Σ.

On returning to its starting point, the moving clock will show a time equal to $2t'$ and the stationary clock a time equal to $2t$. The moving clock must therefore be behind by:

$$2(t - t') = 2\ (1 - 1/\gamma)\ t$$

The delay in moving atomic clocks, as calculated by the special theory of relativity, has been confirmed by numerous experiments, the first of which was carried out by Hafele and Keating in 1971.

The phenomenon of time dilation appears to be a mathematical consequence of the choice of the coefficient Υ in the derivation of the coordinate transformation equations. The experimental results lend physical reality to this phenomenon.

3.2. <u>What are the consequences of the physical reality of time dilation</u>?

Proponents of the special theory of relativity consider that the asymmetry between the stationary clock and the moving clock explains the result and that there is no need to question it further.

For our part, we consider that, as the calculations of special relativity are based on treating the moving clock as equivalent to a clock in the reference frame Σ' during the outward journey, the interpretation of the experiment goes beyond simply explaining the delay in the moving clock.

The physical reality of time dilation implies that, **if the reference frame Σ is considered fixed, time <u>actually</u> passes more slowly in Σ' than in Σ.** This is not merely an illusion.

Let us carry out a similar experiment using the reference frame Σ'. We can deduce from this that, **if the reference frame Σ' is considered to be at rest, time <u>actually</u> passes more slowly in Σ than in Σ'.**

If we assign a physical meaning to time, the two propositions above are irreconcilable. The passage of time in a reference frame cannot depend on whether it is considered to be at rest or in motion relative to another reference frame.

We must therefore conclude that the special theory of relativity leads to a contradiction.

Proponents of the special theory of relativity reject this conclusion. They refuse to link the concept of 'time dilation' to that of 'the passage of time', but do not provide a physical explanation for why the moving clock runs slow.

What is the passage of time?

It can be defined as the succession of identical cycles of a clock. This amounts to saying that the clock embodies the passage of time (the succession of cycles) at the same time as it measures it (counting the number of cycles to determine the duration).

If we adopt this definition, the passage of time is necessarily identical in all reference frames, since all clocks are deemed to be identical to a single standard clock.

There is only one possibility: we must postulate that the passage of time is universal; it is identical in all reference frames.

This implies that no time dilation is observed. However, the operations involved in synchronising clocks in each reference frame do not lead to the absolute time of Newtonian mechanics.

Given relation (6), we must choose $a = \gamma^2$ and $a' = 1$ to write the coordinate transformation equations. We shall elaborate on this in Part 4, highlighting the differences compared with the theory of special relativity.

4. A new approach to relativity

4.1. Universality of the passage of time[11]

Under the assumption of the universality of the passage of time, every event occurs after a duration T – independent of the chosen reference frame – from the origin instant common to all reference frames.

We say that an event is 'produced' in a reference frame if the time shown by the clock at the point to which it is attached is identical to this duration ($t = T$). In a reference frame moving relative to this privileged reference frame, the event is 'perceived' at a different time ($t' \neq T$ unless $x' = 0$).

The reference frame in which an experiment takes place constitutes the privileged reference frame for that experiment. It is this frame that must be regarded as the fixed reference frame Σ for the application of the coordinate transformation equations (2), which become:

$$\begin{cases} x' = \Upsilon^2 \ (x - u\,t) \\ t' = \Upsilon^2 \ (t - u\,x / \mathbf{c}^2) \end{cases} \tag{10}$$

The inverse equations are:

$$\begin{cases} x = x' + u\,t' \\ t = t' + u\,x' / \mathbf{c}^2 \end{cases} \tag{11}$$

It is easy to verify that, with these equations, the absence of time dilation is accompanied by an absence of distance contraction.

[11] See the note *'Another approach to relativity'*, paragraph 2.4.

Equations (11) can be written as follows:

$$\begin{cases} x' = x - u\,t' \\ t' = t - u\,x' / \mathbf{c}^2 \end{cases} \qquad (12)$$

In this form, they can be interpreted perfectly in physical terms:

- at time 't', the operator located at x' in Σ' perceives the abscissa x in Σ; the first equation simply expresses the conservation of distances;

- given the desynchronisation of the clocks, the event occurring in Σ at (x, t) is observed at x' in Σ' at a time shifted by:

$$- u\,x' / \mathbf{c}^2$$

In the form given by (10), the equations show that, at a given time in one reference frame, the image of the other reference frame appears distorted due to the desynchronisation.

For an event occurring at point (x',t') in Σ' (i.e. an experiment taking place in Σ'), the equations are:

$$\begin{cases} x_1 = \Upsilon^2\ (x' + u\,t') \\ t_1 = \Upsilon^2\ (t' + u\,x' / \mathbf{c}^2) \end{cases} \qquad (13)$$

These cannot be obtained by inverting equations (10). For the same pair (x',t'), (x_1 ,t_1) differs from (x,t) in equations (10) and (11).

Furthermore, unlike what is posited by the theory of special relativity, the conjunction of the coordinates x and x' does not constitute a single event, but can be obtained in two different ways, with each observer regarding it as an event occurring within their own reference frame. There is no longer a one-to-one correspondence.

Finally, in the approach we propose, reference frames are not equivalent. Each event is associated with a preferred reference frame, but there is no single absolute reference frame. And the change of reference frame is no longer one-to-one.

4.2. Analysis based on energy considerations [12]

In the Σ reference frame, the total energy[13] of a particle with rest mass $m_0$and velocity v is given by:

$$E = \gamma_v\ m_0\,\mathbf{c}^2 \qquad \text{where} \qquad \gamma_v = 1/\sqrt{1 - \frac{v^2}{c^2}}$$

If we do not assume a priori that the rest mass is invariant under a change of reference frame, the total energy in Σ' is given by:

$$E' = \gamma_{v'} m'_0 \mathbf{c}^2$$

The law of composition of velocities (1) leads to the following relationship between E and E':

$$E' = \gamma\,(1 - u\,v/\mathbf{c}^2)\,(m'_0 / m_0)\,E$$

[12] See the note *'Another approach to relativity',* paragraphs 3.1 and 3.2.

[13] The total energy of a free particle, with neither charge nor angular momentum, is defined here as the sum of its rest energy and its kinetic energy.

Starting from the fundamental equation of dynamics, it is shown that the Lorentz formulas (7) are compatible with the assumption of rest-mass invariance ($m'_0 = m_0$).

The proposed alternative formulae (10), on the other hand, are compatible with the conservation of the particle's total energy, in the sense set out below:

In the reference frame Σ, a particle with rest mass m_0 and velocity u has a total energy of:

$$E = \gamma\, m_0\, \mathbf{c}^2$$

It is postulated that this energy is conserved in the reference frame Σ' where the particle is at rest; its rest mass in Σ' becomes:

$$m'_0 = \gamma m_0$$

Our new approach to relativity therefore leads us to substitute the invariance of total energy for that of rest mass.

4.3. The influence of energy on the rate of clocks

We saw in section 3.1 that a moving (atomic) clock runs slow compared to a clock that remains stationary in a reference frame. Given the assumption of the universality of time that we are working on, **this can only be explained by accepting that the energy level influences the rate of the clock.**[14]

If T denotes the period of a clock at rest and T' the period of the same clock set in motion at velocity u, then:

$$T'/T = E'_0/E_0 = m'_0/m_0 = \Upsilon = 1/\sqrt{1 - \frac{u^2}{c^2}} \qquad (3.17)$$

Depending on the choice of invariant made for energy, this leads to different interpretations of certain phenomena considered as the basis for experimental verification of the special theory of relativity:

- *within the framework of special relativity*, the time lag in moving clocks and the increased lifetime of high-speed atmospheric muons are attributed to time dilation between reference frames; it is assumed that the clocks continue to measure the same unit of time;

- *if one opts to preserve total energy* when changing reference frames, these phenomena are attributed to a change in the rest energy of the atoms in the atomic clock or of the muons, due to the energy received in order to move from reference frame Σ to reference frame Σ'; the passage of time remains unchanged, but the clocks no longer measure the same unit of time.

[14] See the note 'Delay in atomic clocks'

5. Summary table

	Special Theory of Relativity	**Another approach to relativity**
The passage of time	Between two reference frames, clocks appear to be out of sync. There is a phenomenon known as time dilation: the duration between two events, as measured by two separate clocks, is greater than the duration measured by a single clock (proper time).	Between two reference frames, clocks appear to be out of sync. The passage of time is universal. There is therefore no time dilation.
Comparison of reference frames *Events*	All reference frames are equivalent. The intersection of a point in one reference frame with a point in another reference frame constitutes a single event. The mapping between coordinates is one-to-one.	Any event can be associated with a particular reference frame, in which the time shown by the clock at the point where the event occurs is equal to the time elapsed since the origin. The comparison is made between this reference frame and a moving reference frame. The change in coordinates is not one-to-one.
Delay of the clocks relative to motion *Lifespan of muons*	The delay in a moving atomic clock compared with a stationary one is explained by time dilation. Similarly, the increased lifetime of atmospheric muons travelling at high speed.	The delay in a moving atomic clock compared to a stationary one is due to the increase in its total energy as a result of its kinetic energy. The clock's frequency is altered. The same applies to muons.
Speed of the light	The speed of light, $\mathbf{c}$, is the same in all directions and remains constant regardless of the choice of reference frame.	Light emitted by a stationary source in a reference frame travels at speed $\mathbf{c}$ in that reference frame. However, in a moving reference frame, the speed of light is less than $\mathbf{c}$ in directions other than that of the reference frame's motion.
Invariance of energy	Rest mass is invariant under a change of reference frame	Total energy remains constant when the reference frame is changed

The term 'reference frame' implies that it is a Galilean reference frame.

Depending on how the special theory of relativity is formulated, one may consider that the contradiction inherent in it stems from the postulate of the total invariance of the speed of light or from that of the perfect equivalence of reference frames.