38. Simultaneity 3

Links to the book and to other chapters of the book.

38.1 Introduction

This chapter develops an argument involving local simultaneity whose conclusions are relevant to the theory of special relativity, particularly for its completeness. As the reader will see, the simplicity of the arguments leaves little room for doubt and surprise. As in other previous chapters, the involved (uniform) velocity is the velocity of a first object moving through a second object, this second object being at rest in its proper inertial reference frame (RF_o), and in relative motion with respect to a second inertial reference frame (RF_v). Obviously, I repeat again, the trajectory of the first object through the second object is not the same as the trajectory of the first object with respect to RF_v, though the time taken to traverse both trajectories is the same because they start at the same instant and end at the same posterior instant, both instants measured in RF_v.

As in other previous cases in this book, the only alternative of the argument developed in this chapter would be the incompatibility of the theory of special relativity with the concept of uniform velocity (speed) of an object through a second object as the ratio of the length of the traversed object to the time taken to traverse it, both magnitudes measured in the same inertial reference frame, whatever it be. Obviously, both magnitudes (length of the traversed object and time taken to traverse it) are legitimate in any inertial reference frame. What SR would have to declare as unacceptable is the concept of uniform velocity (speed) defined as the ratio between these two magnitudes. If that were the case, such an incompatibility would have to be explicitly declared in the foundations of the theory as a new *ad hoc* restriction.

Until that restriction is made explicit, the arguments related to the referred concept of speed are as legitimate as any other. And when that restriction has been made explicit, which is not the case at present, the theory of special relativity will be an incomplete physical theory according to which certain concepts and physical events cannot be analyzed in all inertial reference frames (for example, all phenomena of optical crystallography could only be analyzed in the proper reference frames of the corresponding crystalline media.). Moreover, this *ad hoc* restriction would raise new doubts about the arbitrary nature of the theory of special relativity.

As will be seen immediately, the key to the new argument consists in proposing the motion of two physical objects in such a way that when they are observed from the inertial reference frame RF_o where they are set in motion, their mutual distance is parallel to the X_o axis of RF_o and increases with time, which implies that in other inertial reference frame RF_v that coincides at a given instant with RF_o and from whose perspective RF_o moves parallel to the X_v axis of RF_v, the distance between both objects in the direction of the relative motion of both frames increases with time. Under these conditions, the successive positions of the two moving objects that are simultaneous in RF_o are not only not simultaneous in RF_v, but are separated by an increasing time interval, which is only possible if one of the objects is accelerated without any force acting on it.

The theory of special relativity is, on the other hand, a theory based on the spacetime continuum, an infinitist concept in turns based on the Axiom of Infinity, which legitimizes the Hypothesis of the Actual Infinity. There are more than 40 different proofs about the inconsistency of this hypothesis, although, as expected, its acceptance is being very slow. The reader of this book has the possibility to examine one of them in Chapter 43. For obvious reasons, if the spacetime continuum is inconsistent, so will be SR.

But then, how is it possible for an inconsistent theory to have so many empirical confirmations? We will have to admit that if we are empirically confirming an inconsistent theory we will have to modify the theory, or reinterpret the empirical evidence, so that we end up with a consistent theory confirmed by that empirical evidence, because a scientific theory can be anything but inconsistent. Two alternatives have already been, and will continue to be proposed, in this book, one based on appearances, the other on the finite discrete nature of space and time, as opposed to the continuous and infinite nature of the relativistic spacetime continuum. But whether consistent or inconsistent, what this chapter demonstrates is that SR is not a complete theory.

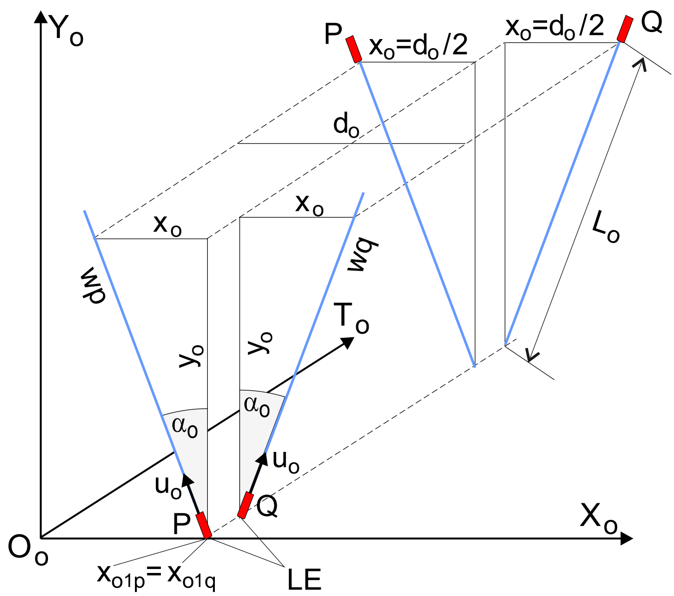

Figure 38.1 – The cylinders P and Q sliding respectively on the inclined wires wp and wq in the proper reference frame RF_o of the wires. Two snapshots are shown: the start of the sliding at the instant $t_{oo} = 0$; and the end of the sliding at the instant t_{o1}.

38.2 Moving along inclined trajectories

As shown in Figure 38.1, P is a cylinder with a hole (parallel to its longitudinal axis) through which it is inserted in a wire wp on which it can slide like the beads of an abacus with a uniform velocity u_o powered by a little engine. Q is another cylinder identical to P, inserted in the wire wq. In their proper reference frame RF_o, the wire wp is on the plane X_oY_o, and the wire wq on a plane parallel to X_oY_o, and so that the lower end of their respective longitudinal axis have the same coordinate on the X_o axis: x_{op} and x_{oq} respectively, so that $x_{op} = x_{oq}$. In addition, both wires are inclined at the same angle α_o, though in opposite directions, with respect to the vertical (parallel to the Y_o axis) of their proper reference frame RF_o.

In this scenario, let us consider the following experience, narrated in the first place from the perspective of the proper reference frame RF_o of the two wires. And then from the point of view of the reference frame RF_v that coincides with RF_o at a certain instant and from whose perspective RF_o moves with a uniform velocity $v = kc$, $(0 < k < 1)$, parallel to the increasing direction of the axis X_v of RF_v. The subindex of the reference frame represents, therefore, the relative velocity at which the wires are observed. The first of the three subscripts of the coordinates of the lower end of P and Q is the subscript of the proper reference frame (o for RF_o and v for RF_v); the second identifies the coordinate itself; and the third one is p (for cylinder P) or q (for cylinder Q), for example:

$$\text{P: } (x_{o1p}, y_{o1p}, z_{o1p}, t_{o1p});\ (x_{o2p}, y_{o2p}, z_{o2p}, t_{o2p}) \ldots \tag{1}$$

$$\text{Q: } (x_{o1q}, y_{o1q}, z_{o1q}, t_{o1q});\ (x_{o2q}, y_{o2q}, z_{o2q}, t_{o2q}) \ldots \tag{2}$$

The cylinders P and Q are initially placed at the lower end of their corresponding wires. At instant $t_{oo} = 0$ of RF_o, and powered by their respective engines, both cylinders P and Q begin to slide up on their respective wires wp and wq with the same uniform velocity u_o. Since the cylinders begin simultaneously to slide and they slide with the same uniform velocity u_o, their corresponding lower ends reach simultaneously the successive points of their respective wires with the same Y_o coordinate. At instant t_{o1} of RF_o both cylinders reach simultaneously the ends of their respective wires and stop. Thanks to the angle $2\alpha_o$ formed by the wires, the distance d_o between the respective LE of the cylinders P and Q increases continuously as the cylinders slide along their respective wires, and they do it according to:

$$d_o = 2u_o t_o \sin\alpha_o \tag{3}$$

This simple detail of the continuous increase of the distance between the cylinders will be of paramount importance in what follows. Note already that this distance is parallel to the direction of the relative motion between RF_o and RF_v. This fact will have consequences on the corresponding increase in the phase difference in synchronization δt_v (local simultaneity) between both reference frames, which according to the Lorentz Transformation and for two clocks placed at the lower ends of P and Q is given by:

$$\delta t_v = \gamma \frac{d_o k c}{c^2} \tag{4}$$

$$= \gamma \frac{d_o k}{c} \tag{5}$$

$$= \frac{d_o k}{c\sqrt{1-k^2}} \tag{6}$$

Assume now that RF_o and RF_v coincide at instant $t_{oo} = t_{vo} = 0$, when P and Q begin to slide. From the perspective of RF_v, the frame RF_o moves according to our standard conditions: with a uniform velocity $v = kc$, $(0 < k < 1)$, in the direction parallel to X_v axis, in the sense of its increasing coordinates. Thus, according to the observers in RF_v:

1. P and Q begin to slide simultaneously at the precise instant $t_{vo} = 0$.
2. The events that are simultaneous in RF_o may not be simultaneous in RF_v. They are not if they are separated by a distance greater than zero in the direction of the relative velocity $v = kc$.
3. Since in RF_o are reached simultaneously all the positions of P and Q in which the lower ends of both cylinders have the same coordinate on the axis Y_o, and in those positions they are separated in the direction of relative motion by a distance d_o greater than zero, those positions are not reached simultaneously in RF_v. They are separated in time by an interval δt_v which, according to the Lorentz Transformation is given by (6).
4. The uniqueness of this experience is that the successive positions of the lower ends of P and Q with the same Y_o coordinate for both, are separated in the direction of the relative motion by a distance that increases as P and Q slide on their respective wires, simply because the original V-shape arrangement of the wires on which they slide.
5. The proper distance d_o that separates the lower ends of P and Q in the direction of their relative motion increases as the cylinders slide on their respective wires: Therefore, the distance d_o increases with the proper time t_o of RF_o according to:

$$d_o = 2\,u_o\,t_o \sin\alpha_o \tag{7}$$

   and the phase difference in synchronization δt_v (lack of simultaneity in RF_v of events that are simultaneous in RF_o) will be given by:

$$\delta t_v = \frac{2k\,u_o\,t_o \sin\alpha_o}{c\sqrt{1-k^2}} > 0 \tag{8}$$

   which increases with t_o, ie. which increases as P and Q slide on their respective wires in their proper reference frame RF_o.

The consequence of $\delta t_v > 0$ is that whenever Q reaches a position with a vertical coordinate y_{vaq}, P had already reached a position with the same vertical coordinate $y_{vap} = y_{vaq}$, and when Q reaches y_{vaq}, the cylinder P is in a position with a coordinate y_{vbp} greater than y_{vaq} (recall, the 'chasing event occurs before'). It remains to examine the consequences of δt_v not being constant but increasing, due to the increasing distance d_o between the lower ends of P and Q in the direction of relative motion; distancing in turn due to the increasing separation of the wires on which P and Q slide; separation finally due to the original V-shaped arrangement of the wires.

To deal with the problem posed by the increasing nature of the function δt_v, let us consider any series of pairs of coordinates on the Y_v axis corresponding to any series of successive and simultaneous positions of the lower ends of P and Q in RF_v:

$$y_{v2p},\ y_{v1q} \tag{9}$$

$$y_{v3p},\ y_{v2q} \tag{10}$$

$$y_{v4p},\ y_{v3q} \tag{11}$$

$$y_{v5p},\ y_{v4q} \tag{12}$$

$$\dots$$

$$\text{Obviously: } y_{v(n+1)p} > y_{vnq};\ \forall n \text{ in the series.} \tag{13}$$

Since the relative velocity between RF_o and RF_v is parallel to the X axes of both reference frames, the Y coordinates measured in both reference frames coincide (Lorentz Transformation). That said, for each subscript n of the above series, the time difference $t_{v(n+1)p} - t_{vnp}$ is the phase difference in synchronization measured in RF_v of two simultaneous events in RF_o: the lower end of P is at vertical coordinate position y_{onp}, and the lower end of Q is at vertical coordinate position y_{onq}; where $y_{onp} = y_{onq}$. Therefore, the above series of couples of coordinates $(y_{vip}, y_{v(i-1)p})$ can be completed by indicating to the right of each pair the corresponding phase difference in synchronization:

$$y_{v2p},\ y_{v1q},\ \delta t_{v1} \tag{14}$$

$$y_{v3p},\ y_{v2q},\ \delta t_{v2} \tag{15}$$

$$y_{v4p},\ y_{v3q},\ \delta t_{v3} \tag{16}$$

$$y_{v5p},\ y_{v4q},\ \delta t_{v4} \tag{17}$$

$$\dots \tag{18}$$

And taking into account that d_o increases as P and Q slide on the wires, and δt_v is an increasing function of d_o we can write:

$$\delta t_{v1} < \delta t_{v2} < \delta t_{v3} < \delta t_{v4} < \ldots \tag{19}$$

Figure 38.2 illustrates this increasing of the relativistic lack of simultaneity in term of the relative velocity (factor k) and the proper separation d_o of the cylinders in the proper reference frame of the wires.

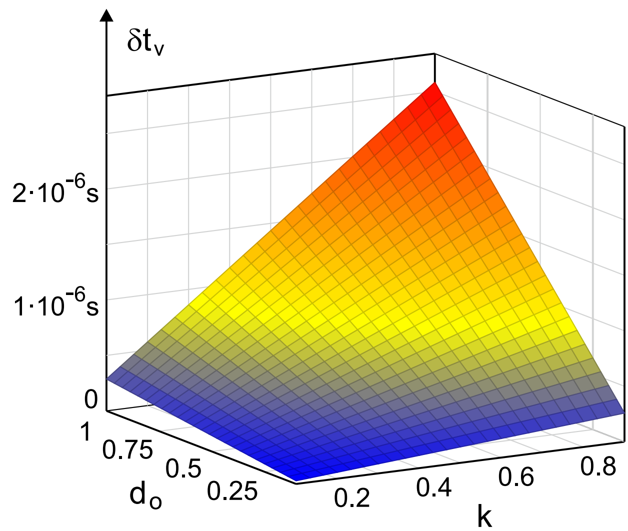

Figure 38.2 – The increasing lack of simultaneity in terms of both the proper distance d_o (in Km) of RF_o in the direction of the relative motion, and the relative velocity factor k.

On the other hand, from (14)-(18) and (19) we can deduce the following physical consequences:

- The event: the lower end of P at y_{v1p} occurs a time δt_{v1} before the event: the lower end of Q at y_{v1q}.
- The event: the lower end of P at y_{v2p} occurs a time $\delta t_{v2} > \delta t_{v1}$ before the event: the lower end of Q at y_{v2q}.
- The event: the lower end of P at y_{v3p} occurs a time $\delta t_{v3} > \delta t_{v2}$ before the event: the lower end of Q at y_{v3q}.

  In general:

- The event: the lower end of P at $y_{v(n+1)p}$ occurs a time $\delta t_{v(n+1)} > \delta t_{vn}$ before the event: the lower end of Q at $y_{v(n+1)q}$.

which, according to (19), can also be written as:

- When moving from y_{v1p} to y_{v2p}, P moves slower than when it moves from y_{v2p} to y_{v3p}
- When moving from y_{v2p} to y_{v3p}, P moves slower than when it moves from y_{v3p} to y_{v4p}
- When moving from y_{v3p} to y_{v4p}, P moves slower than when it moves from y_{v4p} to y_{v5p}
- etc.

Or in other words: from the perspective of RF_v, P moves with an accelerated motion (Figure 38.3). The problem here is that nothing accelerates P, which is confirmed by rotating 90º the wires artifact: now no phase difference in synchronization appears, and then no acceleration appear, neither in P nor in Q. Another rotation of 90º (180º in total) will make the same phase difference in synchronization reappear, but now it will be the cylinder Q that slides with an accelerated velocity.

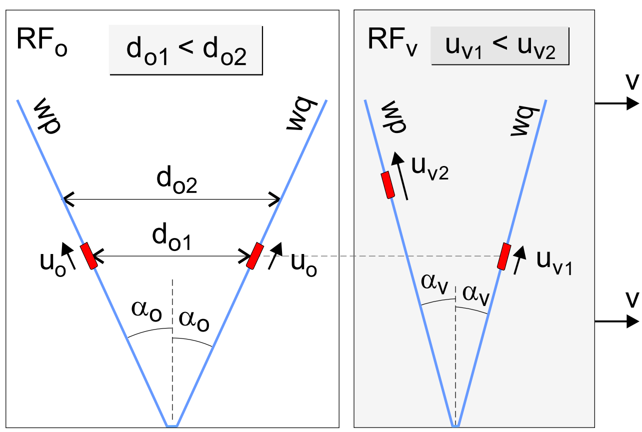

Figure 38.3 – Impossible acceleration of the cylinder P only from the perspective of RF_v.

It is evident that this conclusion, the acceleration of a physical object without a physical cause, goes against several fundamental principles of mechanics, at least against Newton's Second Law, against the Principle of Conservation of Kinetic Momentum and against the Principle of Conservation of Energy. Hence, it must be concluded that either the Lorentz Transformation is inconsistent with all these principles, or the theory of special relativity is incomplete: it cannot be used for the analysis of such physical phenomena as the above sliding of P and Q cylinders, which includes all those physical phenomena and processes involving moving parts inside (or through) other parts. These phenomena and processes could only be analyzed in the corresponding proper reference frames, which obviously goes against the Principle of Relativity (because of its reference to reference frames).

Therefore, we can no longer say that the relativistic deformations of spacetime are due to the discrete nature of space and time, or that they are only apparent. They are actually inconsistent with the fundamental laws of mechanics, or SR is an incomplete theory.

The above conclusion has been obtained by applying the concept of uniform velocity of a body through another body as the ratio between the length of the traversed body and the time spent in traversing it, the traversed body being at rest or in relative motion. When the traversed object is in relative motion, for example with respect to RF_v, the traversing object moves with respect to RF_v along a trajectory that is the sum of its trajectory within the traversed object (trajectory 1) and the trajectory of the traversed object with respect to RF_v (trajectory 2), but the time spent in traversing the trajectory 1 is the same as the time spent in traversing its trajectory 2, because they start at the same initial instant and end at the same final instant. For this reason, the times provided by the Lorentz Transformation can be used in these types of arguments (See Figure 38.4).

To invalidate the above argument would imply prohibiting the application of the concept of uniform velocity as just defined, even though it is permitted to measure lengths and times of moving objects and to draw conclusions from such measurements. Moreover, the prohibition would have to be explicit stated as a new *ad hoc* principle of the theory of relativity.

38.3 Calculation of the ghost acceleration

The above experience of the sliding cylinders on the V-shaped wires admits many variations, including the motion of two photons through two optical fibers, and even trough a vacuum that will be discussed in the next sections. For all these variations, the following deduction of the formula expressing the impossible acceleration that all these objects would have to undergo is valid. Obviously, its mathematical expression will allow us to evaluate it in graphic and quantitative terms.

Recall again that, although we are not referring the motion of the cylinders to the reference frame RF_v, but to the wires on which they

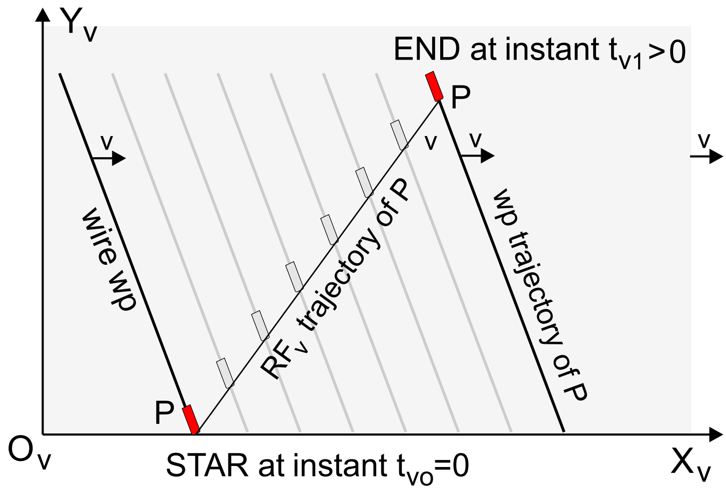

Figure 38.4 – The trajectory of the cylinder P with respect to the reference frame RF_v and with respect to the wire wp on which it slides.

slide, the time t_v spent by the cylinders in their motion with respect to RF_v is the same time spent in traversing their respective wires: both motions start at the same instant ($t_{vo} = 0$)) and end at the same posterior instant ($t_{v1} > 0$), and therefore have the same duration $t_v = t_{v1} - t_{vo}$ (Figure 38.4).

Taking into account that $\gamma^{-2} = 1 - k^2$, and being L_v the length of the wires from the perspective of RF_v, we can write (see Figure 38.1):

$$x_o^2 = L_o^2 \sin^2 \alpha_o;\; y_o^2 = L_o^2 \cos^2 \alpha_o \tag{20}$$

$$L_v^2 = \gamma^{-2} L_o^2 \sin^2 \alpha_o + L_o^2 \cos^2 \alpha_o \tag{21}$$

$$= L_o^2((1 - k^2) \sin^2 \alpha_o + \cos^2 \alpha_o \tag{22}$$

$$L_v = L_o \sqrt{1 - k^2 \sin^2 \alpha_o} \tag{23}$$

Let us represent by δt_v the phase difference in the synchronization between the event P reaches the upper end of its wire wp, and the event Q reaches the upper end of its wire wq.

Since each cylinder takes the same time to traverse its corresponding wire as its trajectory with respect to RF_v, if t_v is the time taken by Q in both trajectories, we can write:

$$t_v = \gamma t_o + \gamma \frac{d_o k}{c} \tag{24}$$

$$= \gamma t_o + \delta t_v \tag{25}$$

$$t_v - \delta t_v = \gamma t_o \tag{26}$$

where δt_v is the difference in time between the arrival of the two cylinders at the end of their respective wires. Therefore, the difference Δ_{pq} between the velocity of P and the velocity of Q will be:

$$\Delta_{pq} = \frac{L_v}{t_v - \delta t_v} - \frac{L_v}{t_v} \tag{27}$$

$$= \frac{\delta t_v L_v}{t_v(t_v - \delta t_v)} \tag{28}$$

$$= \frac{\delta t_v L_v}{t_v \gamma t_o} \tag{29}$$

In reaching that speed difference, P has needed a time $t_v - \delta_v = \gamma t_o$. Therefore, P has undergone an acceleration a_{vp}:

$$a_{vp} = \frac{\delta t_v L_v}{t_v \gamma^2 t_o^2} \tag{30}$$

To express a_p in terms of the relative velocity $v = kc$ between RF_o and RF_v, the length L_o of the wires, the angle $2\alpha_o$ between them, and the separation d_o of their upper ends in the direction of relative motion, we simply take into account that:

$$u_o = L_o / t_o \tag{31}$$

$$u_{ox} = u_o \sin \alpha_o \tag{32}$$

$$d_o = 2 L_o \sin \alpha_o \tag{33}$$

$$L_v = L_o \sqrt{1 - k^2 \sin^2 \alpha_o} \tag{34}$$

Thus, (30) can be successively rewritten as:

$$a_{vp} = \frac{\delta t_v L_v}{t_v \gamma^2 t_o^2} \tag{35}$$

$$= \frac{\frac{\gamma d_o k}{c} L_o \sqrt{1 - k^2 \sin^2 \alpha_o}}{\gamma \left(t_o + \frac{d_o k}{c} \right) \gamma^2 t_o^2} \tag{36}$$

$$= \frac{d_o k L_o \sqrt{1 - k^2 \sin^2 \alpha_o}}{(ct_o + d_o k) \gamma^2 t_o^2} \tag{37}$$

$$= \frac{d_o k (1 - k^2) L_o / t_o \sqrt{1 - k^2 \sin^2 \alpha_o}}{(cL_o/u_o + d_o k)(L_o/u_o)} \tag{38}$$

$$= \frac{d_o k (1 - k^2) u_o \sqrt{1 - k^2 \sin^2 \alpha_o}}{(cL_o/u_o + d_o k)(L_o/u_o)} \tag{39}$$

$$= \frac{d_o u_o k (1 - k^2) \sqrt{1 - k^2 \sin^2 \alpha_o}}{(cL_o + d_o k u_o)(L_o/u_o^2)} \tag{40}$$

$$= \frac{d_o u_o^3 k (1 - k^2) \sqrt{1 - k^2 \sin^2 \alpha_o}}{(cL_o + d_o k u_o) L_o} \tag{41}$$

$$= \frac{2 u_o^3 k (1 - k^2) \sqrt{1 - k^2 \sin^2 \alpha_o}}{(c 2 L_o / d_o + 2 k u_o) L_o} \tag{42}$$

$$= \frac{2 u_o^3 k (1 - k^2) \sqrt{1 - k^2 \sin^2 \alpha_o}}{(c \csc \alpha_o + 2 k u_o) L_o} \tag{43}$$

38.4 Moving along inclined transparent rods

The following argument is similar to the previous one, it simply replaces the sliding cylinders and their respective wires by two photons moving through two transparent rods arranged in the same way as the wires. The photons also move from the lower end to the upper end of their respective rods. So, let RF_o and RF_v be the same inertial reference frames of the previous section, A and B two identical transparent rods of proper length L_o and with the same refractive index n. Let now a^* and b^* be two photons emitted simultaneously in RF_o from the lower ends of their respective transparent rods A and B in the direction parallel to their respective longitudinal axis. So, in each rod photons move from one end of the rod to the other. Evidently, in the proper reference frame (RF_o) of the transparent rods, the photons a^* and b^* travel the same distance L_o through their respective rods A and B, whose endpoints are separated by a proper distance d_o, parallel to the direction of the relative motion between RF_o and RF_v.

From the perspective of RF_v, the reference frame RF_o moves with velocity $v = kc$, $(0 < k < 1)$, parallel to X_v, and according to the above argument, the photon a^* will undergo an acceleration a_{a*} as it moves from the lower end to the upper end of the rod A, which is separated from the upper end of the rod B by a proper distance d_o. To calculate the acceleration a_{va^*} of a^* we must replace u_o in (43) with the speed c/n of light through the transparent rods:

$$a_{va*} = \frac{2(c/n)^3 k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{(c\csc\alpha_o + 2kc/n)L_o} \tag{44}$$

$$= \frac{2c^3 k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{n^3(c\csc\alpha_o + 2kc/n)L_o} \tag{45}$$

$$= \frac{2c^2 k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{n^2(n\csc\alpha_o + 2k)L_o} \tag{46}$$

The acceleration of the photon a^* is deduced in accordance with the time given by the Lorentz Transformation (which, recall is the same for both trajectories of each photon: with respect to its corresponding rod and with respect to RF_v), but it is beyond any physical possibility. For example, for a rod of 100 m of refractive index of 1.1 inclined at an angle of 45° and moving at a relative velocity $v = 0.0001c$, we would have:

$$L_o = 0.1 \text{ Km} \tag{47}$$

$$k = 0.0001 \tag{48}$$

$$\alpha_o = 45^\circ \tag{49}$$

$$a_{va^*} \approx 95481928.27 \text{ Km}/s^2 \tag{50}$$

So, after a second of this acceleration the speed of light would be greater than 48 millions Km/s, which needs no comment on its absurdity.

38.5 Accelerated photons in the vacuum

Let us now replace the transparent rods by two long cylindrical tubes A and B in which the vacuum has been made (a vacuum that does not exist in any of the involved reference frames: RF_o and RF_v.). At the bottom of each tube, an emitter emits photons along their respective longitudinal axis. At the other end of each tube is a photon sensor that emits a flash of light of a visible color (e.g. green) when hit by a photon arriving in the direction of the tube's longitudinal axis. Both tubes are arranged as shown in Figure 38.5.

Suppose that in each tube A and B a photon is fired at the same instant 0 of RF_o-time, the proper reference frame of tubes A and B. After a time t_o both photons simultaneously reach the other end of their respective tubes, collide properly with their corresponding photon sensor and two flashes A and B of visible green light are emitted, one in each tube.

Again, two simultaneous events in RF_o, the emission of flashes A and B, are not simultaneous in RF_v, from whose perspective the tubes move with relative velocity $v = kc$, $(0 < k < 1)$; and the trajectory of each photon in its corresponding tube is completed in the same time as its trajectory with respect to RF_v: both trajectories are different but they start at the same instant 0 of time in RF_v and end at the same instant t_v of time in RF_v[1]. We are then in the same conditions of the two previous arguments, and we can apply equation (43) to calculate the acceleration a_{a^*} of the photon a^*, replacing now the velocity u_o of the cylinders P and Q with the velocity c of light in vacuum. We will have:

$$a_{va^*} = \frac{2c^3k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{(c\csc\alpha_o + 2kc)L_o} \tag{51}$$

$$= \frac{2c^3k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{c(\csc\alpha_o + 2k)L_o} \tag{52}$$

[1]The fact that each photon fires its corresponding flash having been emitted in the direction of the longitudinal axis of the tube by a source in relative motion, is only possible thanks to the preinertia: the vector inheritance that each photon receives from the relative velocity vector of its emitting source.

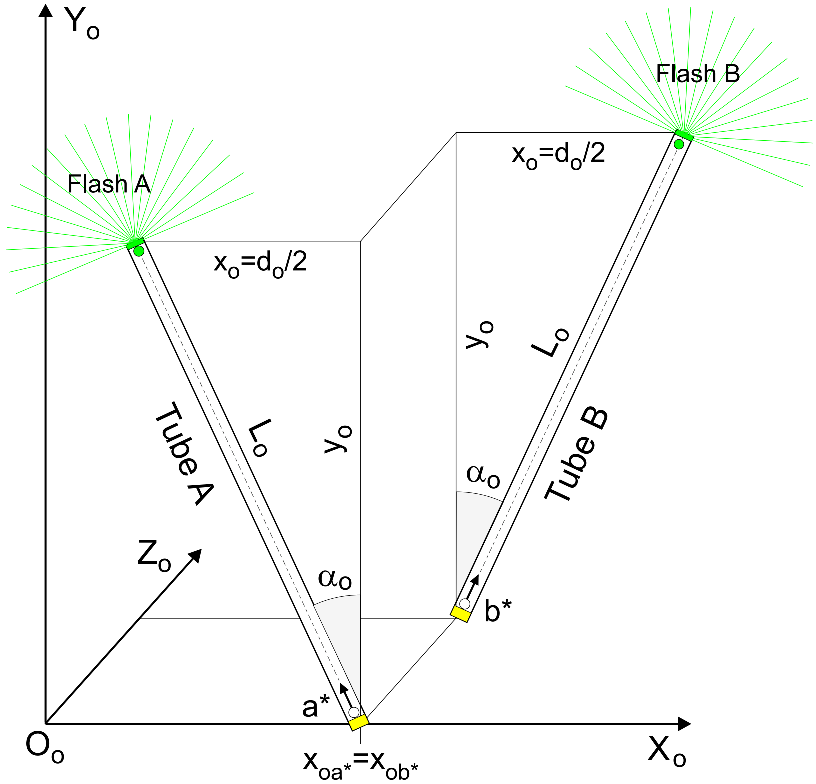

Figure 38.5 – In the proper reference frame RF_o of tubes A and B, two photons moving along the axis of their respective tubes simultaneously reach their corresponding sensors and two flashes of visible green light are simultaneously emitted.

$$= \frac{c^2 k(1-k^2)\sqrt{1-k^2\sin^2\alpha_o}}{(\csc\alpha_o + 2k)L_o} \tag{53}$$

As illustrated in Figure 38.6, the resulting values for this self-acceleration of photons in a vacuum (without any force acting on them) are as even more absurd than in the above case of the transparent media.

38.6 Conclusion

According to the absurd results of the above arguments (conclusions deduced from the relativistic local simultaneity), it is only possible to conclude that the analyzed phenomena, although they are logically, physically and mathematically legitimate objects of knowledge, cannot be the object of study of the theory of the special relativity. Consequently, this theory is incomplete. And the reason can be none other than the fundamental principles of the theory itself, particularly the

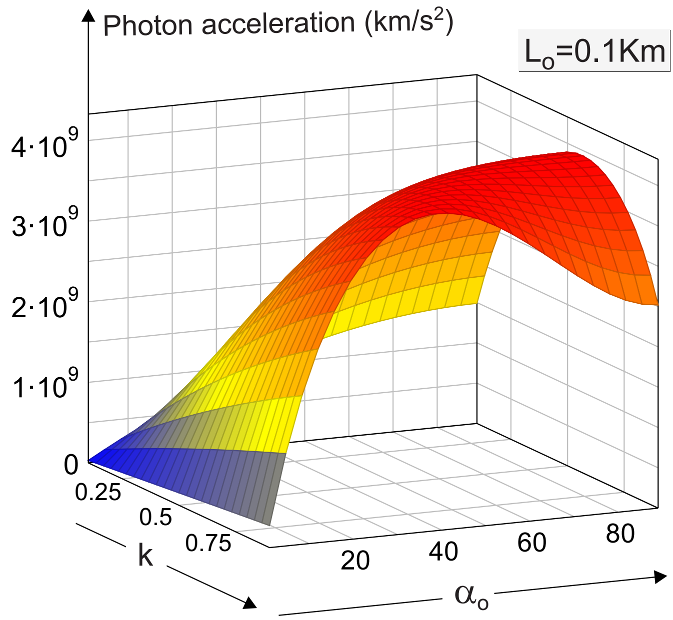

Figure 38.6 – Self-acceleration of photons in a vacuum due to local simultaneity.

Principle of Relativity, which explicitly refers to reference frames:

> The laws of physics are the same in all reference frames.

or in Einstein's words[111, p. 895]:

> 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 coordinates in uniform translatory motion.

The classic statement of the naturalists of the 19th century:

> Natural laws are the same in all places and at all times.

does not cause this type of problem because, as in the rest of the fundamental principles of experimental sciences, no reference is made to reference frames (all of them arbitrary, except the universe itself).