

SPECIAL APPENDIX

REMARKS ON THE FOUNDATIONS OF SPECIAL RELATIVITY

(i) Questions of consistency

Along with my old doubts about the determination of Newtonian gravitation constant G , as recalled in Part II of “*Vacuum, Vortices & Gravitation*”, other doubts do ever since harass me concerning the way in which Lorentz first, and Einstein later, cast the foundations of the theory of special relativity.

Lorentz pointed out the need in physics for a clearer definition of “time” in describing observed events. He began focusing on the need to define “operationally” what we should consider as “simultaneity”, when the same event is observed from two different points in space, say point A and point B located at any distance r from each other in a Euclidean space. He stated that the assessment of the speed of any object moving from A to B (or *vice versa*) implies the synchronisation of two clocks, of a same standardised type, one placed in A and the other one in B .¹ Lorentz began with the analysis of events observed from an “inertial system S ”. An inertial system may be defined as a set of physical objects each of which is in a *rest state* with respect to all the other ones, none of them being subject to any kind of acceleration. An inertial system may be considered as either at absolute rest or in motion at a linear uniform speed.

Suppose that in two distinct fixed points A and B , belonging to the same inertial system S , there are two different observers, one in A and the other in B , who use an identical type of clock to record the passage times of an object P in a uniform motion along the straight line that connects A to B . Object P may be viewed as a different inertial system in a linear uniform motion with respect to S .

Lorentz remarks that when P is seen in A by the local observer it cannot yet be seen by the observer in B , for the light – the speediest signal in nature – takes an amount of time $\tau = r/c$ to reach B from A , if r is the distance between the two observers and c is the speed of light. Lorentz excludes the possibility of synchronising two clocks in A and then taking one of them to B . Another important assumption, which was later turned into a postulate by Einstein’s theory of special relativity (**SR**), is that speed of light c is a universal constant, whatever its propagation direction, irrespective of any physical reference frame. Therefore, the passage of P recorded in A by the local observer at time t_A is “simultaneously” recorded by the observer in B at time $t_B = t_A + \Delta t = t_A + r/c$.

Substantially, though not explicitly - and apart from $c = \text{universal constant}$ - the very special postulate made by Lorentz is the following: *Within any inertial system, the “yard-sticks” used to measure distances are rigid, i.e., they do not change their length if moved around for measurement purposes, whereas any kind of clock may in general change its pace if it moves from any point to another of the system.*²

Therefore, for Lorentz, the only operational possibility of synchronising clocks is keeping them steady in each observation point of the inertial system considered, and using electromagnetic signals (light) for synchronisation purposes.

¹ My first question is why two synchronised clocks are necessary for this purpose.

² From a mere logical standpoint, *rigid* yard-sticks moved inside an inertial system for measurement purposes are in a substantial contradiction with Lorentz transformation Formula [2] shown in subsequent Page 3.

In this context, the reason for assuming/postulating the physical “impossibility” to move any clock from A to B of an inertial system is not clear to me. It might have been suggested to Lorentz by the fact that the pace of clocks like pendulums depends on gravity acceleration, and gravity acceleration varies from point to point of the Earth not only in relation to the latitude and altitude, but also at different points of equal latitude and altitude because of not fully explained reasons, as shown by the long lasting use of gravimeters across the world (see also Footnote 40, Page 42, of *Vacuum, Vortices and Gravitation*, Part II).³

The oscillation period T (the pace) of a pendulum is expressed by $T = 2\pi\sqrt{l/g}$, in which l is the length of the pendulum’s rod or wire, and g is the local gravity acceleration. One has to consider that all clocks and watches – up to the first three or four decades of the 20th century – were regulated with reference to sample pendulums⁴. Clearly, this fact is not sufficient to explain Lorentz’s assumption about clocks, also because pendulums cannot be used within an inertial system, for inertial systems – by definition – do not undergo acceleration. Nevertheless, if one moves clocks from one point to another of any inertial system does also give the clocks accelerations that – while modifying their speed and physical state – might also modify their pace, though no analogous criterion Lorentz applies to the yard-sticks to be used within the same system, otherwise one could never know any reliable measurement of the distance between points of the system.

For one reason or another, a physicist of Lorentz’s stature felt impelled to get rid of clocks whose pace may be influenced by their physical state or local environmental conditions, in order to refer to time-measuring devices consistent with the specific state of an inertial system (though Lorentz was certainly aware that the concept of “inertial system” is a simplifying hypothesis, if it is true that the cosmic space is everywhere a field of forces). However, Lorentz’s assumption about synchronisation had provided a first operational criterion to get rid of Newtonian *absolute time* in physics. In dealing with physical events occurring within any physical system in uniform motion with respect to another reference inertial system, the use of only one reference clock of any kind is sufficient to assess how the time runs inside the other systems observed, since the motion of the reference clock is compared only to the universally uniform motion of light.

Lorentz’s assumption about synchronisation has heavy implications. The first of these is the way in which, from a given reference inertial system S , the time relevant to another inertial system S' must be accounted for. The relation between time t' in S' and time t in S is expressed by the following well-known Lorentz transformation formulas:

$$t' = t \sqrt{1 - \frac{v^2}{c^2}} = \frac{t - \frac{vr}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} \quad [1]$$

in which $v = \text{constant}$ is the speed of S' with respect to S , and r is the distance between S and S' as seen from S , at time t in S : i.e., $v = r/t$; while c , as usual, is the speed of light.

³ In 1672, during his stay in Cayenne, French astronomer Jean Richer could observe that the oscillations of his pendulum were slower than in Paris. At low latitudes, the Earth’s rotation speed is higher than at temperate latitudes. Thus, at the tropical latitude of Guyana also the kinetic energy of pendulums is higher than in Paris.

⁴ Together with pendulums, clock hands were also set in motion by sort of contrivances based on weights and counterweights obviously moved by gravity. Though the use of metallic springs to activate clocks began in the 16th century, it must be noted that the pace regulation and repeated re-adjustment to these clocks had always to refer to the regularity of given sample pendulums. However, it must be considered that the formula for pendulum period T given above is only an approximation adopted for small oscillations. More complex general equations describe the oscillations of pendulums.

The *relative time* defined by [1] leads to the other well-known Lorentz transformation formula

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}} \quad [2]$$

in which x' expresses the unit length of r as measured in and from S' with respect to unit length x as measured in and from S . Therefore, according to Formulas [1] and [2], both time and distances reveal shorter for S' than for S , in a way that depends on the relative speed v and on the ratio of this to the speed of light c . The greater the speed v the greater the delay of t' with respect to t , and the shorter length unit x' with respect to length unit x .

If recession speed is $v = 0$, then time and length measurements are identical for S and S' , whereas the two formulas above make no physical sense if $v = c$.

Let's also remember that Lorentz – like most physicists of his time – was convinced that the physical space is everywhere permeated with a special substance, the ether, whose only tested property is to allow the propagation of light and all electromagnetic waves at constant speed c . In an analogy with the speed of sound in the air, Lorentz assumed that – *with respect to the ether* – the speed of any electromagnetic signal does not depend on the speed of either the signal's source or receiver. Similarly, for two birds that fly in the atmosphere the speed of their mutual call *across the air* is constant and does not depend on the relative speed of their flight. Moreover, as discussed in Paragraph 3.3 of *Vacuum, Vortices and Gravitation*, time – for most purposes in physics – can be considered as the ratio of any studied motion to a different uniform motion taken as a reference. With a view to avoiding the recourse to Newtonian absolute time, Lorentz decided that there is no better reference motion than that of the light across the ether. Formulas [1] and [2] are two consequences of assuming the motion of light across the ether as a basic reference motion in physics. Ambiguities concerning the interpretation of these formulas may in part vanish if one considers that what of S' is seen from S is symmetrical to what of S is seen from S' . Lorentz's assumptions may actually be viewed as an indirect way to consider the ether as an absolute reference frame.

In connection with the preceding notes it's worth observing that Special Relativity shows a theoretical gap. Formulas like [1] or [2], along with the other ones that involve the square root factor $1/\sqrt{1 - v^2/c^2}$, give imaginary values for relative speed $v > c$. Which has led to state that no physical object can travel faster than the speed of light. However, considering that speed v is *relative* to any inertial reference frame, there is an unanswered question as to the fate of quantities such as lengths, masses and times, when two physical systems accelerate along opposite directions up to receding from one another at a *relative* speed that exceeds the speed of light but doesn't exceed c with respect to the ether. According to Relativity this is impossible, but it's not difficult to show that it's instead thinkable. Einstein's Special Relativity claims that no transmission medium of light can be assumed as an absolute reference frame, but Einstein's postulate – according to which the speed of light doesn't add with the speed of either the light's source or detector – is an implicit assumption that the transmission medium of light is the absolute reference frame. Actually, in the second half of his life, Einstein felt impelled to recognise this fact.

Two different systems can be thought of as moving with respect to each other at a speed that is higher than the speed of light. Let's imagine a source of light, placed in the origin O of the reference frame S of **Figure 1** ahead, which sends a continuous electromagnetic signal in all directions. Moving from point O , and along the same axis X , two other different systems, S' and S'' , accelerate in opposite directions, i.e., one following the positive X , the other one along the negative X . Even in Special Relativity, there is no conceptual impediment to thinking that

both accelerating systems S' and S'' can eventually achieve a speed, with respect to the source of light O in S , not too far from c , say 200,000 km/sec. If so, this also means that, with respect to each other, the two systems, S' and S'' , travel now at 400,000 km/sec (or more) recession speed, which is remarkably greater than the speed of light. Obviously, no direct electromagnetic connection is possible between S' and S'' , though they could in principle communicate through S , since each of them is still in condition to catch the signals from O and to send signals to S .

In this thought example the theoretical framework of Special Relativity shows its logical limits, in that statements such as the *impossibility* of travelling faster than the speed of light loose significance, if one claims to generalise the concept, while no credible explanation can be provided as to the *physical fate* of systems like the two S' and S'' imagined above.

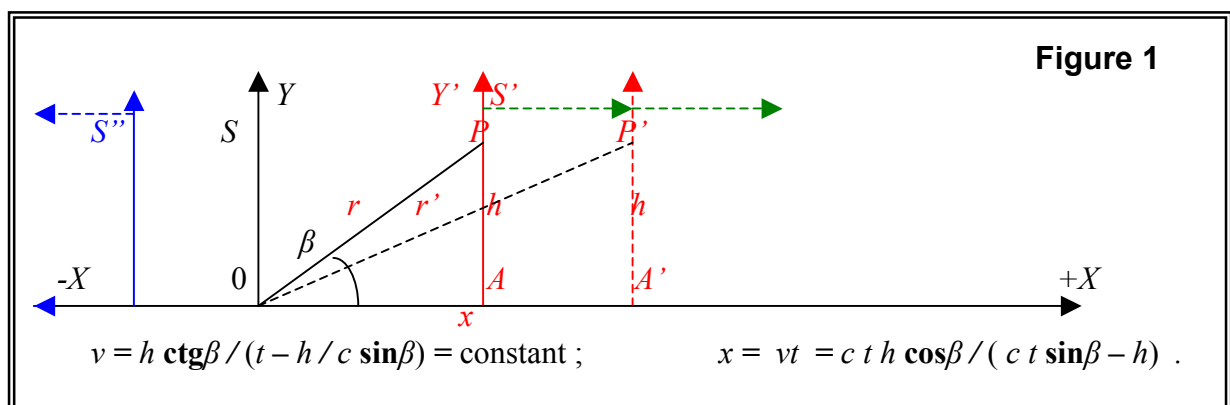
(ii) Inertial relative motion

In my opinion, all the ambiguity associated with relativistic formulas like [1] and [2] depends on three facts, two of which are not accounted for by the theory of relativity:

- (a) there is no way to assess the absolute speed of any inertial system with respect to the ether;
- (b) there is no clear indication on how it is possible for S to assess the relative speed of S' (or *vice versa*), when the two inertial systems are isolated in the cosmic space;
- (c) there is nowadays confirmed experience that two identical clocks, after initial synchronisation and whatever their working mechanism, do actually display different times at the conclusion of any sort of "round trip" made by one of them at an adequate high speed with respect to the other one.

The **SR** formulated by Einstein disregards point (a) above, after considering that no absolute reference frame is necessary to the internal consistency of the theory.

As to point (b), there are at least two ways to assess the relative speed of any inertial system S' in a linear uniform motion with respect to another inertial system S , taken the latter as the reference one, though the theory of relativity doesn't provide any specification as to this issue. The most obvious way of the two can be illustrated by the aid of **Figure 1** here below.



It must be supposed that the two systems considered, S and S' , are objects of at least one dimension measured along axis Y of a Cartesian reference frame, otherwise S' would be invisible from O .

Suppose also that S' is seen from S as in receding motion from S along co-ordinate X , and that a physical dimension h on co-ordinate Y' of S' is known. Then, a couple of measurements are sufficient to assess the recession speed v of S' and whether v is a constant speed. In fact,

by optical measurement of the angle β in O formed by $r = OP$ with X , the distance $x = OA$ is given at time t in O by $x = h \operatorname{tg}\beta$, while distance OP is given by $r = h/\sin\beta$.

However, at moment t , when r is recorded in O , system S' (its point A in particular) has moved ahead during the travel of the light received in O from P , which took a time $\tau = r/c = h/c \sin\beta$. Therefore, the value of speed v is actually expressed by

$$v = \frac{h}{\left(t - \frac{h}{c \sin \beta}\right) \tan \beta} = \frac{ch \cos \beta}{ct \sin \beta - h} = \text{const.};$$

whence one derives the actual distance $x = OA$ at time t in O , i.e.,

$$x = vt = \frac{cth \cos \beta}{ct \sin \beta - h} \quad [3]$$

Analogous operations can be repeated at any time $t+\Delta t$ to verify the constancy of speed v .

It seems obvious that quite symmetrical operations are possible if one considers system S as receding from S' , after placing the observation point in A . Whatever the clocks used, either in S or in S' , the values calculated in S' for both speed v and distance x *cannot* differ from the relevant values calculated in S .

The symmetry of the situation described is total, for there is no way to establish which of the two systems is in motion, or whether *both* of them are in motion or not. Moreover, it is difficult to recognise the need for any synchronisation of clocks in S with clocks in S' in describing physical events with either reference to S or S' . Let alone the other question that I, for the sake of mathematical precision, ask myself about the physical meaning of the “+” and “-“ signs, which I didn’t write but *should* instead be associated with the square root operations shown by relativistic Equations [1] and [2].

In simpler words, it seems to me that the problem of synchronisation is a false problem, and the attempt at resolving it through the relativistic approach recalled above leads to the formulation of questionable conclusions. In particular, the reason why clocks cannot be moved from one point to another of the same inertial system has been left unexplained by Lorentz relativity. This point has been either omitted or ambiguously addressed by various authors of texts on Relativity. Let’s see just a few examples amongst the many possible ones: Christian Møller, a renowned Danish physicist, wrote:

“*Any other method [different from the relativistic one] for synchronising the two clocks [placed one] in A and [one] in B , like for instance the transport of a third clock from A to B , clashes against the same fundamental difficulty*”⁵;

but one cannot identify, in that entire text by Møller, any “*same fundamental difficulty*” which could work as something at what Møller hints. Even Born’s arguments for justifying the relativistic assumptions about synchronisation seem tottering, thus strengthening the impression that Equation [1] above should be considered as a hypothesis rather than a thesis of relativity.⁶ Amongst other authors and more recently Massimo Brighi wrote:

“*...in [space-]ship A we synchronise two identical clocks and then we send one to spaceship B . The main problem of this solution is that - according to relativity itself - any clock in motion slows its pace down; and this is not only a theoretical prediction, but a true fact which*

⁵ Christian Møller, “*Relatività*”, Enc. del Novecento, VI, Page 74, Istit. Encicl. Ital., Roma 1982.

⁶ Max Born, “*Einstein’s Theory of Relativity*”, Dover Publications, 1962, Chapter 6.

has clearly been proven by experiments carried out with atomic clocks. Therefore, clocks transported [from A to B] at different speeds would result in different synchronisations”⁷; this is – on the one hand – a classical example of *petitio principii*, in that which is to be demonstrated is taken for granted, and is – on the other hand – also an example of how one can introduce postulates (as done - though not explicitly - by Lorentz and Einstein) in the lucky wait for any later relevant corroboration/confirmation. Which nowadays turns Lorentz’s and Einstein’s postulate (or hypothesis) into a sort of self-evident truth for Brighi. When Lorentz and Einstein formulated their relativistic theories no reference to such self-evidence would have been possible. The fact recalled by Brighi, however, appears more as something still to be properly explained, rather than a clear confirmation of relativity.

Another method for assessing the mutual recession speed, either from S or from S' , is endowing both O of S and A of S' with an identical source of light that sends a continuous electromagnetic signal at a given frequency ψ in all directions.

The mutual recession speed can in this case be measured through the Doppler effect associated with the recession motion of any source of light. In the cosmic space, at any given relative recession speed v of any source of light, whose proper emission frequency is ψ , corresponds a frequency ψ_v perceived by the observer of the recession, as expressed by the following simple relation

$$\psi_v = \psi \left(1 - \frac{v}{c}\right), \quad [4]$$

which gives – in the case of recession motion – a measurement of the so-called *red shift*. The red shift is a constant value if recession speed v is constant; otherwise it varies with v . Thus, speed v is immediately determined by

$$v = c \left(1 - \frac{\psi_v}{\psi}\right) \quad \text{along with distance} \quad x = t c \left(1 - \frac{\psi_v}{\psi}\right). \quad [5]$$

If $v = \text{constant}$, the values for v and x calculated in S are the same as in S' , irrespective of the clocks used in each system. From the first of the above relations one gets

$$\left(1 - \frac{\psi_v}{\psi}\right) = \frac{v}{c} . \quad [5a]$$

It’s however important to remark that v is not in general considered with respect to the plenum (or ether), but only with respect to the speed of light: Equations [4] to [5a] do not exclude the physical possibility of a mutual recession speed which exceeds the speed of light, though – in such a case – the same equations would make no sense. In the above analysis, which is based on relative speeds detected through the transmission of electromagnetic signals, the same equations are significant as far as electromagnetic connection between systems in motion is possible.

As to the last point (c) listed in page 4 above, I wish to remark that one thing is to express the concept of “time” in terms of abstract kinematics, a quite different thing is the *physical measurement* of time in physics, which is based on dynamic behaviours and operations. If experience proves that alterations occur in the behaviour of clocks in different dynamic states, this should not necessarily prove that the only plausible explanation for that is provided by

⁷ Massimo Brighi, “*Simultaneità relativistica*”, in “*La natura del tempo*”, edited by F. Selleri, Dedalo, Bari 2002, Pages 230 on.

relativity. Similarly, Ptolemaic system could with a high precision predict eclipses, but this fact has not been sufficient to establish that the Ptolemaic system is the only adequate theory to explain eclipses. Clocks are material contrivances that undergo the effects of changes in their physical state; such an obvious statement doesn't seem to require a general and universal explanatory theory. Nevertheless we could try to approach the issue in a simple manner, allowing for *not unreasonable* examples about what clocks are in practice.

(iii) When the relative recession motion is accelerated

Let's now suppose that the two systems S and S' of Figure 1 are initially in an identical inertial state, characterised by a linear uniform speed v , so that points O and A , shown in **Figure 1** above, are not in motion with respect to each other.

At a certain moment t , system S' starts receding from system S under any acceleration a . Therefore, the two systems are in a relative accelerated recession motion, but the effects of the acceleration can be detected only in S' , the objects in this system being now subjected to a force whose strength is the product of their mass and the acceleration undergone.

S' is no more an inertial system. The force generated by the accelerated motion of S' could - for instance - set a pendulum in motion, whereas this is still not possible in system S , which hasn't changed its inertial state.

Yet, the mutual recession speed can – instant by instant – be assessed through the Doppler effect, though the situation is now asymmetrical: at each different value assessed for recession speed v_r - from either S or S' - different dynamic states must be considered for the two systems. Whatever constant speed v of inertial system S , its kinetic energy remains constant with time, whereas the kinetic energy of system S' increases with time as long as its acceleration lasts.

We can also suppose that initially, when S and S' are in the same inertial state, time is measured inside each system by identical caesium clocks. Caesium clocks exploit the very high regularity of the oscillations of this metal's atoms when these are excited by a controlled beam of microwaves. The use of this kind of high-precision clocks is possible also in absence of gravity, but it is not allowed to think that these clocks are insensitive to changes in their speed.

The cubic crystal lattice of caesium compels the atom of this metal to make highly constrained and regular oscillations about its oscillation centre. However, as it is of any atom in any material, the atom's oscillation amplitude and frequency undergo the effects of changes in the material's pressure or temperature or any other changes in the metal's physical state. The oscillation keeps the atom under a central force that can schematically be described by the harmonic motion equation:

$$m \frac{d^2s}{dt^2} + ks = 0 \tag{6}$$

in which m is the atom's mass, s is the elongating distance of the centre of mass of the atom from the oscillation centre, and k is the specific elasticity constant of the material. As known, the solution of Equation [6] is given by

$$s = D \cos\left(t \cdot \sqrt{\frac{k}{m}} \pm \phi\right), \tag{7}$$

in which D is the oscillation amplitude, i.e., the maximum distance (or elongation) of the atom's mass centre from the oscillation centre, and ϕ is the integration constant that indicates the oscillation phase. Elongation s is the oscillation amplitude D when $t\sqrt{k/m} + \phi = 0$, and $t = T/4$, i.e., when

$$T = \pm 4\phi \sqrt{m/k} \tag{8}$$

in which T is the oscillation period.

Let’s now imagine that system S' , once achieved a certain speed V at any distance r from S , stops its acceleration and continues moving at speed $V = \text{constant}$. Every mass unit of S' has at that moment acquired an increment in its kinetic energy which, remembering Equations [5] - and for mass m in particular, can be expressed by

$$\Delta E'_m = \frac{m(V^2 - v^2)}{2} = \frac{mc^2(1 - \frac{\psi_V}{\psi})^2}{2} \quad [9]$$

in which ψ_V is the frequency of the electromagnetic signal detected by both S and S' in relation to the mutual recession speed V . One can now express the new situation in S' as if every mass unit of S' has been augmented by an amount

$$\Delta m' = \frac{\Delta E'_m}{c^2} = \frac{m(1 - \frac{\psi_V}{\psi})^2}{2}, \quad [10]$$

which reflects on the atom’s oscillation period, according to the following relations (remember also [5a] above):

$$T'_V = \pm 4\phi \sqrt{\frac{m + \Delta m'}{k}} = \pm 2\phi \sqrt{\frac{2m \cdot [2 + (1 - \frac{\psi_V}{\psi})^2]}{k}} = \pm 2\phi \sqrt{\frac{2m \cdot (2 + \frac{V^2}{c^2})}{k}}. \quad [11]$$

This relation shows there is an expansion of the atom’s initial oscillation period T , which means a lowering of the atom’s oscillation frequency, as a consequence of the intervened quantity $\Delta m' = m(1 - \psi_V/\psi)^2/2 = mV^2/2c^2$ that adds to the atom’s mass in S' (see [10] above). Therefore, a slowing down of the clock’s pace in S' occurs – during its acceleration – with respect to the clock’s pace at its initial speed v .

Once S' has achieved its new uniform speed V , the delay expressed by $\Delta T = T'_V - T$ doesn’t change further, as it remains constant along with $V = \text{constant}$. It should now be clear that in this situation the clocks in S differ from the clocks in S' : the difference in their pace means that *the times they display do now belong to different measurement systems*.⁸

(iv) *Speed and time measurement*

According to the preceding simple analysis, one may argue that the delays shown by clocks in motion at uniform relative speed does ultimately depend on different initial accelerations undergone by the relevant systems, and do not depend on their relative speed. In other words, if one doesn’t know which of the systems has undergone an acceleration with respect to the other, the uniform relative speed as such is not sufficient to make one establish in which system the clocks delay and whether they delay or not in any one of the systems.

In the light of the preceding analysis, one might conclude that the *cause* of the pace alteration in clocks *after* acceleration is the same as the cause of their pace alteration under gravity effect, for in both cases differences in time measurement depend on the effect of acceleration, i.e., on changes in speed. In this connection, it must be pointed out that changes in the clock’s pace *are not a function* of the acceleration *itself*, but only of the acceleration’s effect, which consists of the change in the kinetic energy of the clock’s oscillating masses. In

⁸ It’s worth thinking that slower clocks in S' do not *per se* imply that people in system S' slow their aging down.

proper terms, the clock’s pace changes because of the change in its speed, which involves a change in the kinetic energy of the clock. The clock’s *acceleration* may have an identical intensity because of either an increase or *decrease* of its speed, but the effects of the acceleration are different in the two cases. If the speed increases, the clock slackens its pace; if the speed decreases, the clock hastens its pace.

As to the effect of gravity on the pace of clocks, one should consider that gravitational forces entail motion in every case, at either macro or micro scale. One way or another, matter subjected to gravity moves along trajectories/paths at either constant or variable speed, often according to the effects of other possible forces that combine with gravity.

By definition, gravity accelerations are inevitably associated with speeds. This is an implication of the gravity potential intrinsic to any gravity field. Basically, the physical dimension of gravity potential is a square speed, which – multiplied by the mass of a material body – expresses the intrinsic content of the body’s kinetic energy due to the gravity field only. This particular energy content may be viewed either in the macro-motion of the whole body with respect to the gravity centre or in the micro motion of its elemental components (molecules, atoms, etc.).

A mere gravitational motion, due to the gravity field only, does entirely develop the gravity kinetic energy of the mass involved. If other forces constrain the body in non-orbital motion, part or all of the gravity kinetic energy is retained by its atoms or molecules in the form of heat caused by acceleration pressures.

Beside the preceding remarks, it’s appropriate pointing out, in particular, that the kinetic energy of any particle of matter in a circular motion depends only on its variable or constant speed along the circular path. A stable *identical central acceleration* regime may be maintained by any particle in a circular motion *under different conditions of uniform circular motion/speed*, according to appropriate choices of the radiuses and periods of the relevant circular trajectories. (For example: consider two bodies, both of mass m , at *different uniform speeds*, V and v , on two different circular orbits whose radiuses are R and r , respectively, T and t being the respective motion periods. The two bodies are subjected to identical central accelerations **if** $V = vT/t$).

Once again to conclude that also within gravity fields mass oscillation frequencies depend on the relevant kinetic energy, be it constant or variable.

Experiments have been carried out or are still in progress to better understand how time is measured by clocks in different relative motions as well as how the life-time of atomic elements modifies under various dynamic conditions.⁹ It must be said that much uncertainty prevails as to the conclusions to be drawn from the findings of those researches, because in no case one can neglect that any material object, in order to achieve any final speed, must first undergo acceleration. Discussions are in fact recorded on whether or not – or in which cases – acceleration should be accounted for in assessing the behaviour of clocks in motion.

Finally, it seems worth observing that one may consider the energy E_m of any mass unit m – whatever the relevant physical state – as expressed by the difference between two kinetic energies, *i.e.*, between the *actual* kinetic energy of the mass in motion (after a series of accelerations) at any speed V **with respect to the ether/plenum**, and the *minimum* kinetic energy of the mass in its absolute minimum motion with respect to the plenum/ether (“rest mass m_o ” corresponding to $\psi = \psi_o$, after assuming that ψ represents the frequency of the wave

⁹ A useful synthesis concerning the state of the research in this field has been written by Michele Barone, “*Ritardo degli orologi in moto*” [“The pace slowing down of clocks in motion”], in “*La natura del tempo*” [The Nature of Time] ed. by F. Selleri, *op. cit.*, Pages 101 to 110.

associated with any component of mass m). In such a case, the energy increment ΔE_m coincides actually with E_m . Considering [10] and [5a] above, in fact, the *active mass* (denote it as m_V ¹⁰) is given by

$$\Delta m_0 = m_V = \frac{m_0}{2} \left(1 - \frac{\psi_V}{\psi_0}\right)^2 = \frac{m_0}{2} \left(\frac{V}{c}\right)^2, \quad [12]$$

so that the total mass m^* , *at rest within the inertial system to which it belongs*, is expressed by

$$m^* = m_V + m_0 = m_0 \left(1 + \frac{V^2}{2c^2}\right), \quad [13]$$

and its *actual energy*, if $v_0 \cong 0$ (remember also relation [9]), is expressed by

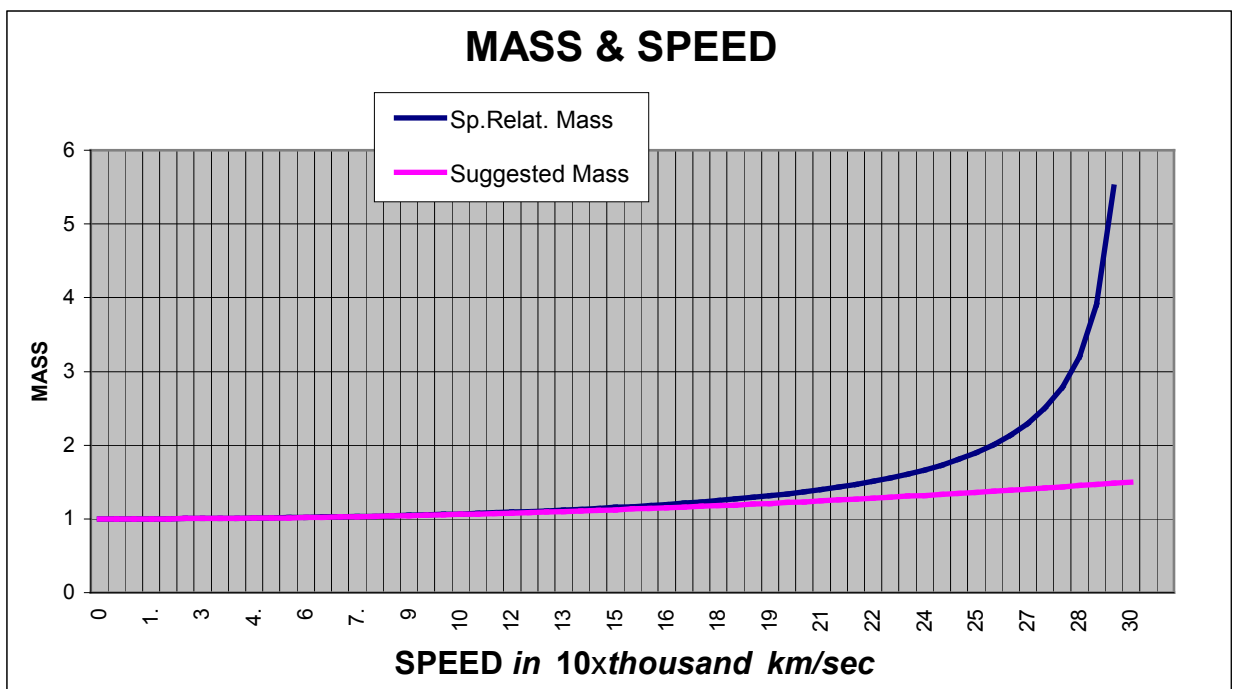
$$\Delta E_m \equiv E_m = m_V c^2 \equiv \frac{m_0}{2} V^2. \quad [14]$$

The meaning of these equations is here obvious, provided that speed V is considered with respect to the plenum/ether. It's important to remark that *Equations [12] to [14] do not exclude the possibility that speed V exceeds the speed of light.*

The conclusion that follows is now inevitable. In whatever inertial system, it is theoretically impossible to decide whether the system's speed, including speed zero, is a consequence of previous accelerations undergone by the same system; though it must in general be assumed that accelerations occurred, and some sort of motion is in progress, unless

¹⁰ It's the mass that carries kinetic energy.

¹¹ The graph below shows how mass ratio m^*/m_0 expressed by this equation varies with speed, in a comparison with the variation undergone by the same mass ratio according to Special Relativity. Up to about $V = c/2$, the two curves are substantially coincident. For $V = c$ the relativistic curve indicates an infinite value for mass, whereas the other curve shows that the value achieved by mass at speed c is finite and equal to $m_c = 1.5m_0$.



one thinks it is realistic considering quite an exceptional system which stands “absolutely still” ever since, i.e., from the origin of the Universe.

If it’s reasonable to think of any physical object as of in motion with respect to the “plenum”, then, *whatever the relative speed* V , Equation [14] is true of any physical system in the Universe, so that the same equation may simply be written as $E = m c^2$.

In a more general way: consider Equation [13] after multiplying it by c^2 , to write, because of [14],

$$m^* c^2 = (m_v + m_o)c^2 = m_o V^2 / 2 + m_o c^2, \quad [15]$$

which means that *the increment in the mass energy* indicated by Equation [14] can also be expressed as

$$\Delta E_m = m_o V^2 / 2 = m^* c^2 - m_o c^2, \quad [16]$$

if V is the mass speed *with respect to the plenum*. Therefore, Equation [16] above leads one to conclude inevitably that

$$E = m^* c^2 = m_o V^2 / 2 + m_o c^2 \quad [17]$$

does in general *express the total energy content* of any mass m^* in *whatever state of motion*.

By consideration of states of kinetic energy, an analogous conclusion ($E = m c^2$) can be derived from assumptions proper to special relativity, though the same equation - as shown by Einstein himself - can be proved true through more than one way of reasoning, to mean that it is not an achievement inherent in Special Relativity only.¹²

(v) *Superluminal motion*

In the absence of viable cosmological alternatives, scientists feel compelled to stick to the relativistic conclusions of Lorentz-Einstein’s theories as to the “impossibility” of any superluminal motion. Nowadays, it’s common belief that “nothing can travel faster than the speed of light”.

The situation of our present scientific knowledge is obviously conditioned by the limits intrinsic to current scientific theories, even against the evidence provided by very significant observations, which should instead induce scientists to doubt what they believe they know.

At least since 1981,¹³ in observing the *strange* very long linear flares, or “jets” orthogonal to galaxy disks, which are currently associated with the activity of the galactic nuclei,

¹² Since a few decades, some articles and essays try to question Special Relativity as to the speed limit (the speed of light) *imposed* on the physical world by that theory. One of the topics addressed for the purpose consists of the discussion on and the interpretation of the so called “entanglement” described by quantum-mechanics, which involves the generation of pairs of particles whose physical states remain apparently interconnected, irrespective of the distance that may intervene between them. The debate re-proposes, in particular, the physical possibility of *absolute simultaneity*, which was instead ruled out by Special Relativity.

It is not my intention to avail myself of such a topic: in my view, most of the discussion on the subject does either focus on a false problem (“locality”/ “non-locality” of our universe) or draw arbitrary conclusions.

From another side, starting from 1967, Gerald Feinberg and followers developed a theory based on “tachyons” (particles speedier than light), picturing a hypothetical world where the speed of light is the unattainable *minimum* speed. Their work was proposed as complementary to Special Relativity.

¹³ See I. J. Pearson & al., “Superluminal Expansion of Quasar 3C273”, *Nature*, vol. 290, April 1981.

See also R. Porcas, “Superluminal Motion: Astronomers Still Puzzled”, *Nature*, no. 28, April 1983, and R. J. Davis, S. C. Unwin, T. W. B. Muxlow, “Large scale superluminal motion in the Quasar 3C273”, *Nature*, No. 354, Dec. 1991.

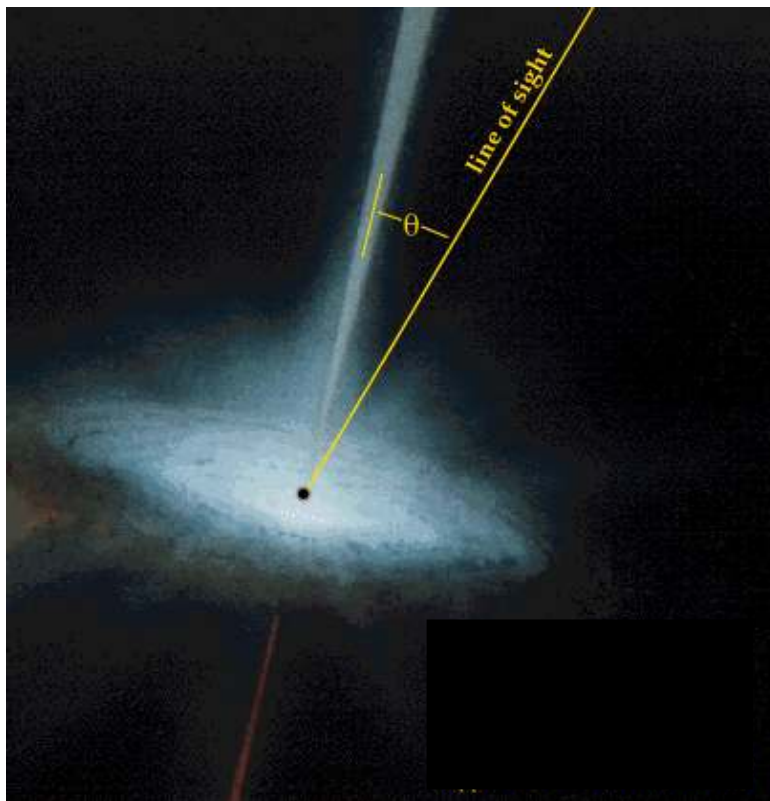
More recently, J. A. Biretta, W. B. Sparks, F. Machetto, “Hubble Space Telescope Observations of Superluminal Motion in the M87 Jet”, *Astrophysical Journal*, vol. 520, Aug 1999.

astronomers detected superluminal motions in the material particles of which those “jets” consist.

During the last two decades, there have been several attempts to explain the phenomenon, though the explanations given may be accepted under particular conditions only. An initial explanation was accepted for superluminal motions detected in galaxy flares whose alignment is close (within a 19 degree deviation) to the line of sight. However, superluminal motions were later observed also in galaxy flares whose alignment is almost perpendicular to the line of sight, and the explanations for the observed phenomenon became questionable. The “apparent” speed of the superluminal motions observed attains 4 to 9.6 times the speed of light.

In my opinion, there is already enough stuff to question the speed-of-light limit seriously.

In connection with the arguments presented in the preceding sections of this essay, in particular with a reference to assumptions made in *Part III* and in the *Second Appendix*, such superluminal motions can naturally be explained with respect to the *true vacuum* or to the *nothingness* that forms along the linear rotation axis of a ring-vortex as well as in the ring core of ring-vortices. Part of the analyses and calculations I have carried out in preceding sections of this essay are based on the hypothesis that the speed of the plenum at the boundary with the vortex nucleus or core is more than 2.5 times the speed of light. The astronomic observations mentioned above do actually suggest that the maximum speed of the plenum *at its contact* with the true vacuum may be much higher than expected: which might remarkably modify a few quantitative conclusions of my analyses based on the *source speed* of vortices.



There is no clear explanation for the origin of the galaxy “flares”. These involve extremely high – and even superluminal speeds of material particles. This essay provides one of the possible explanations, which is connected to the hypothesis that the “flares” are the visible action of ring-vortices of “plenum”(i.e., of physical space) travelling across the same medium. See the detailed description of the vortex shape, structure and motion in preceding “Second Appendix”. Moreover, the length of such “flares” should approximately correspond to the size of the “spherical vortex” into which the ring-vortex transforms when moving across the plenum.