

SPECIAL APPENDIX

REMARKS ON THE FOUNDATIONS OF SPECIAL RELATIVITY

At variance with a largely shared opinion, both the foundation and the logical structure of Special Relativity (SR) have substantially been laid by Hendrik Lorentz¹ and by Henri Poincaré², not by Albert Einstein. Yet, the mathematical generalisation of SR comes from Hermann Minkowski³, who in 1907 proposed the *spacetime* reference frame in its current notation, though the first mathematical formulation and use of a *spacetime* reference frame was clearly made by Poincaré⁴ in June 1905. (“Spacetime” is also referred to as “chronotope”).

As pointed out by Hermann Weyl⁵:

*“One of the interesting historical aspects of the modern relativity theory is that, although often regarded as the highly original and even revolutionary contribution of a single individual, almost every idea and formula of the theory had been anticipated by others. For example, Lorentz covariance and the inertia of energy were (arguably) implicit in Maxwell’s equations. Also, Voigt formally derived the Lorentz transformations in 1887 based on general considerations of the wave equation. In the context of electro-dynamics, Fitzgeral, Larmor, and Lorentz had all, by the 1890s, arrived at the Lorentz transformations, including the peculiar time dilation and length contraction effects (with respect to the transformed coordinates [i.e., the spacetime]) associated with Einstein’s special relativity. By 1905, Poincaré had clearly articulated the principle of relativity and many of its consequences, had pointed out the lack of empirical basis for absolute simultaneity, had challenged the ontological significance of the ether, and even demonstrated that the Lorentz transformations constitute a group in the [mathematical] sense as do Galilean transformations. In addition, the crucial formal synthesis of space and time was arguably the contribution of Minkowski in 1907, and the dynamics of special relativity were first given in modern form by Lewis and Tolman in 1909”.*⁶

Of a particular interest is also the book of another mathematician and historian, Edmund Whittaker, who, in a chapter titled “*The Relativity of Lorentz and Poincaré*”, credited Poincaré

¹ Hendrik Antoon Lorentz, Dutch scientist (1853-1928): *Versuch einer Theorie der elektrischen und optischen Erscheinungen in bewegten Körpern*, Brill, Leiden 1895; *Electromagnetic phenomena in a system moving with any velocity smaller than that of light*, Proceedings of the Academy of Science, **1**, Amsterdam 1904.

² Henri Poincaré, French mathematician and physicist (1854-1912): *La théorie de Lorentz et le principe de réaction*, Archive Néerlandaise des Sciences Exactes et Naturelles, **5** (1900), *Les relations entre la physique expérimentale et la physique mathématique*, Revue générale des sciences pures et appliquées, **11** (1900), *L’état actuel et l’avent de la physique mathématique*, Bulletin des sciences mathématiques, **28** (1904), and *Sur la dynamique de l’électron*, Comptes Rendus **140**, June 1905

³ Hermann Minkowski, Lithuanian-German mathematician (1864-1909): *Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern*, Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physicalische Klasse (1907)

⁴ H. Poincaré, *Sur la dynamique de l’électron* (reprint), Rendiconti del Circolo Matematico di Palermo, **21** (1906).

⁵ Hermann Weyl, German mathematician and historian of science (1885-1955): *Space, Time, Matter*, Methuen & Co., London 1922; Ch. II, Para. 21-22

⁶ In this connection it is also worth considering that the paper on relativity published in 1905 by Einstein (*Zur Elektrodynamik bewegter Körper*, Annalen der Physik, **17**) contains no mention of *spacetime* concept, which was at that time not yet part of Einstein’s thought. Only later Einstein became acquainted (arguably through Minkowski) with Poincaré’s work concerning the *spacetime* identified by Lorentz transformations.

and Lorentz for developing SR, while attributing almost no importance to the 1905 paper on relativity published by Einstein. According to Whittaker⁷, the famous formula $E = mc^2$ must also be attributed to Poincaré.⁸

The preceding annotations are a due premise to the analysis that follows, in which I intend to account for the difference existing between SR as is nowadays practiced and Einstein’s SR. In my view, this implies also a distinction between Einstein’s SR and the set of the major concepts on relativity formulated by his predecessors. Such a distinction is unusual within the academic world, but is instead necessary to understand the weakness of the foundation of Einstein’s SR.

(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 and Poincaré first, and Einstein later, laid 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. In Lorentz-Poincaré’s view, 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 .⁹ Lorentz proposed the analysis of events observed from two different systems in uniform motion with respect to each other.

Suppose that in two distinct fixed points A and B , belonging to the same 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 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 $c = \text{universal constant}$ - a special assumption made by Lorentz seems to be the following: *Within any 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*

⁷ Sir Edmund Taylor Whittaker (1875-1956), English mathematician: *A History of the Theories of Aether and Electricity*, Nelson, London 1952-1953.

⁸ H. Poincaré, in analysing the characteristics of electromagnetic fields, could show that the energy (E) of an electromagnetic wave is like that of a fluid medium whose mass density is proportional to E/c^2 . *La théorie de Lorentz et le principe de réaction*, *Archive néerlandaise des sciences pures et appliquées*, 11, 1900 (op.cit)

⁹ Simultaneity *in itself* seems rather a conventional concept. In principle, synchronisation can never be ascertained for separate clocks.

from any point to another of the system.¹⁰ (I am stressing this point because it seems incompatible with the other Lorentz equation concerning *relative* lengths and distances).

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

In this context, the reason for assuming/postulating the physical “impossibility” to move any clock from *A* to *B*, after synchronising the clocks in *A*, 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).¹¹

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 pendulums¹². Clearly, this fact is not sufficient to explain Lorentz’s assumption about clocks. Nevertheless, if one moves clocks from one point to another of any physical 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, as pointed out by Poincaré, Lorentz paved the way 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 any system. In simpler words, 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 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 system *S*, the time relevant to another system *S’* in relative uniform motion 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:

¹⁰ From a mere logical standpoint, *rigid* yard-sticks moved inside any system for measurement purposes are in a substantial contradiction with Lorentz transformation Formula [2] shown in subsequent Page *s.a.* 4.

¹¹ 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 tropical latitudes, the Earth’s rotation speed is higher than at temperate latitudes. Thus, at the latitude of Guyana also the kinetic energy of pendulums is higher than in Paris.

¹² 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. (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).

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad \text{or else} \quad t' = t / \sqrt{1 - \frac{v^2}{c^2}}, \quad \text{if } x = 0; \quad [1]$$

in which $v = r/t = \text{constant}$ is the speed of S' with respect to S , x is any abscissa in S along the motion direction; r is the distance between S and S' ; while c , as usual, is the speed of light.

The *relative time* defined by [1] is tied to the other well-known transformation formula that Lorentz did introduce as a hypothesis to explain the “failure” of Michelson-Morley experiment:

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

in which x' expresses the unit length as measured in and from S' with respect to the unit length x as measured in and from S . Therefore, according to Formulas [1] and [2], both time and distances, measured from S , reveal shorter when measured in 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 . Not to forget, nevertheless, that the situation referred to S becomes symmetrical if referred to S' . The ambiguity of this point has been questioned by Herbert Dingle seriously.¹³

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

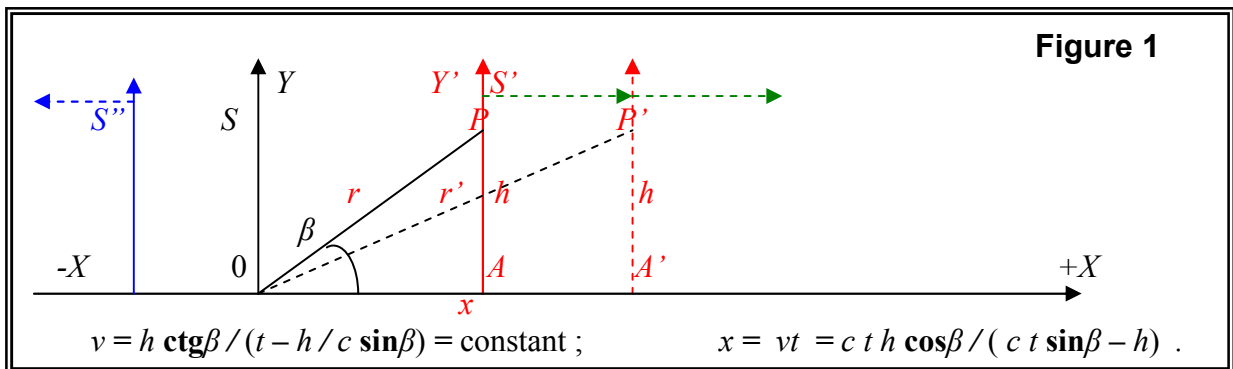
Let's also remember that Lorentz – like most physicists of his time – was convinced that the physical space is everywhere permeated with a special substance, the ether, whose only tested property is to allow the propagation of light and all electromagnetic waves at constant speed c . In an analogy with 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; and ambiguities concerning the interpretation of these formulas may partly vanish if one thinks that Lorentz's assumptions are viewed as a 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 any other one that involves 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 nothing can travel faster than the speed of light. However, considering that uniform speed v is *relative* to any 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

¹³ “The theory [special relativity] unavoidably requires that *A* works more slowly than *B* and *B* more slowly than *A* ...which requires no super-intelligence to see is impossible”. Page 17 of *Science at the Crossroads*, by Herbert Dingle, M. Brian & O’Keeffe, London, 1972. Dingle, English physicist and professor at Imperial College, after being a militant relativist, found reasons for changing his mind concerning Einstein’s Special Relativity. See also *The Case against Special Relativity*, Nature **119**, 1967.

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 Einstein's SR 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; in this connection, see also the attachment to *Part I* of *Vacuum, Vortices and Gravitation* herewith.

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** above, 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 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 Einstein's SR shows its logical limits, since statements such as the *impossibility* of travelling faster than the speed of light lose 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. In that case, the relativistic composition of velocities makes no sense: the sum of the velocities (v for S' and $-v$ for S'') with respect to S would be nil [the relativistic composition is $w = (v-v)/(1-v^2/c^2)$].

(ii) Inertial relative motion

In Lorentz-Poincaré relativity, the consideration of the ether as an absolute reference brings in itself reasonable answers to the issue concerning the two systems S' and S'' , for the composition of relative velocities is independent of the speed of light to the extent that all velocities refer to the ether. In Einstein's SR, instead, the problem becomes complicated due to the two postulates that characterize his theory.

First of all, Einstein's SR accounts only for *inertial systems*. 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. *No force* can be detected within an inertial system. Any inertial system may be considered as either at absolute rest or in motion

with a linear uniform speed, since no *absolute reference* is allowed for.

Instead, what matters in Lorentz-Poincaré SR transformations [1] and [2] is only the speed relative to the ether, so that motion can also occur in presence of forces like, for example, that of either gravity or gravitation. It’s a very important difference, which makes Lorentz-Poincaré SR a theory with its own pertinent dynamics, always bearing in mind that Lorentz’s relativity develops with respect to the ether.

Einstein’s SR postulates (Einstein’s *relativity principle*) that electromagnetic laws do not change their form with respect to any *inertial* reference frame ¹⁴. The second postulate of Einstein’s SR is that the speed of light is constant in all directions and *independent of the motion of any systems*. On this basis, Einstein’s SR arrives at the same relativistic formulas proper to Lorentz-Poincaré relativity, including Formulas [1] and [2], as well as at the other important equation which expresses *mass* as a function of its “relative” speed, i.e.:

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \quad [3]$$

in which m is the mass that moves with “relative” speed v , whereas m_0 is the same mass “at rest” with respect to the relevant reference frame. Equation [3] (actually regarding the “transverse mass” of a body in relative motion) is due to Lorentz, and it appears also in the definition of kinetic energy formulated by Einstein in analysing the motion of an electron. ¹⁵

In my opinion, all the ambiguity associated with relativistic formulas like [1], [2] and [3] depends on three facts, which are not accounted for by the theories of special 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 of how it is possible for S to assess the relative speed of S' (or *vice versa*), when the two systems are isolated in the cosmic space;
- (c) there is confirmed experience that two identical clocks, after initial synchronisation and whatever their working mechanism, display different times at the end of any sort of “round trip” made by one of them at a high relative speed with respect to the other one;
- (d) moreover, in Einstein’s relativity, the concept of “inertial system” seems quite metaphysical: not only is there no way to imagine a physical system totally free from external forces, but also the concept of “mass” itself escapes all physical significance, considering that within an inertial system there is no means for assessing the “rest mass” m_0 .

In Lorentz-Poincaré relativity, instead, relative motion *does not* necessarily imply *inertial systems*. Consider – for instance – a terrestrial artificial satellite moving with uniform speed along a circular orbit with respect to a fixed reference frame having its origin in the Earth’s center. This orbital motion is planar, uniform in speed but not in *velocity*, since the velocity vector of the satellite (the direction of its speed’s intensity) changes continuously. In association with the varying velocity vector, the satellite is constantly subject to a pair of equal and opposite forces (the gravity centripetal force and the corresponding centrifugal force), which put the material body of the satellite under a permanent tension stress. Lorentz, in fact, had to consider any mass moving with a uniform speed along a *non linear route* as characterized by three *mass-components* relevant to the varying *longitudinal* and *transverse* velocity

¹⁴ Should this regard electromagnetic laws only, Einstein’s postulate would simply be obvious and useless, since Maxwell’s field equations are mathematically expressed, in vector notation, by operators “rotor” and “divergence” that make the laws of electromagnetism *per se* independent of any reference frame, be this inertial or not.

¹⁵ A. Einstein, *Zur Elektrodynamik bewegter Körper*, Annalen der Physik, 1905, *op. cit.*, Para. 10. The formula for kinetic energy is there given by $E_k = (m - m_0)c^2$, where $m = m_0 / (1 - v^2/c^2)^{1/2}$ as per Equation [3]. When considered within Lorentz’s paradigm, Equation [3] for (*transverse*) mass does not necessarily refer to uniform *velocity*.

components, with the respective acceleration components (while the *speed* may or not remain a scalar constant). In the paradigm of Lorentz relativity, *mass* is interpreted as a *vector inertia*, and Equation [3] there describes the *transverse mass*. This, however, cannot be considered as pertinent also to Einstein’s special relativity, which is constructed upon the linear and uniform motion of *inertial* systems, in which *transverse* and *longitudinal mass* should intrinsically exclude any relevant acceleration.

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 theories of relativity do not provide any specification as to this issue. The most obvious way of the two can be illustrated by the aid of **Figure 1** above.

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 length 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.,

$$x = vt = \frac{ct h \cos \beta}{ct \sin \beta - h} \quad [4]$$

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 .

If one considers inertial systems, the symmetry of the situation described is total, for there is no *a priori* 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 Special Relativity. This point has been either omitted or ambiguously addressed by various authors of texts on Special 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*”¹⁶;
 though 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 Equations [1] above should be considered as an assumption rather than a thesis of relativity.¹⁷ Amongst other authors and more recently Massimo Brighi wrote:

“...in [space-]ship A we synchronise two identical clocks and then we send one to space-ship 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 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”¹⁸ ;
 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 theses in the lucky wait for any later relevant corroboration/confirmation; which nowadays turns Lorentz’s and Einstein’s thesis 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 Special 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

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

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

$$v = c \left(1 - \frac{\psi_v}{\psi}\right) \quad \text{along with distance} \quad x = t c \left(1 - \frac{\psi_v}{\psi}\right). \quad [6]$$

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

$$\left(1 - \frac{\psi_v}{\psi}\right) = \frac{v}{c} . \quad [6a]$$

¹⁶ Christian Møller, *Relatività*, Enc. del Novecento, VI, Page 74, Istit. Enc. Ital., Roma 1982.

¹⁷ Max Born, *Einstein’s Theory of Relativity*, Dover Publications, 1962, Chapter 6. However, also Joseph Larmor (1857-1942), before Lorentz and Einstein, gave a reasonable *physical* explanation for time dilatation relevant to matter in motion, in his book *Aether and Matter*, Cambridge Univ. Press, Cambridge 1900.

¹⁸ Massimo Brighi, *Simultaneità relativistica*, in “La natura del tempo”, edited by F. Selleri, Dedalo, Bari 2002, Pages 230 on.

It’s however important to remark that v is in general considered with respect to the speed of light, which also means with respect to the plenum (or ether): Equations [5] to [6a] 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 phenomena 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 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

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

At a certain moment t , system S' starts receding from system S with 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 subject 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 the 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 one 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:

$$m \frac{d^2s}{dt^2} + ks = 0 \quad [7]$$

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 [7] is given by

$$s = D \cos\left(t \cdot \sqrt{\frac{k}{m}} \pm \phi\right), \quad [8]$$

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

$$T = \pm 4\phi \sqrt{m/k} \quad [9]$$

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 [6] - and for mass m in particular - can be expressed by

$$\Delta E'_m = \frac{m(V^2 - v^2)}{2} = \frac{mc^2 \left(1 - \frac{\psi_V}{\psi}\right)^2}{2} \quad [10]$$

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

$$\Delta m' = \frac{\Delta E'_m}{c^2} = \frac{m \left(1 - \frac{\psi_V}{\psi}\right)^2}{2}, \quad [11]$$

which reflects on the atom’s oscillation period, according to the following relations (remember also [6a] above):

$$T'_V = \pm 4\phi \sqrt{\frac{m + \Delta m'}{k}} = \pm 2\phi \sqrt{\frac{2m \cdot \left[2 + \left(1 - \frac{\psi_V}{\psi}\right)^2\right]}{k}} = \pm 2\phi \sqrt{\frac{2m \cdot \left(2 + \frac{V^2}{c^2}\right)}{k}}. \quad [12]$$

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 $\Delta m' = m \left(1 - \psi_V / \psi\right)^2 / 2 = m V^2 / 2 c^2$ that adds with the atom’s mass in S' (see [11] 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*.¹⁹

¹⁹ Slower clocks in S' do not *per se* imply that people in system S' slow their aging down. In the two different systems age is measured by different time units. In this connection, it’s also worth considering that “the twins’ paradox” does not pertain to Einstein’s special relativity, for such a case involves accelerations, whereas Formulas [1] in Einstein’s special relativity regard inertial systems only.

(iv) Speed and energy measurement

From the preceding simple analysis, one may infer that the delay shown by clocks in motion at uniform relative speed does ultimately depend on different initial accelerations undergone by the relevant systems, and does 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 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 subject to gravity moves along trajectories/paths with 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 multiplied by the mass of a material body, which 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 pressure (or tension).

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 gravitational orbits whose radiuses are R and r , respectively, T and t being the respective orbital periods. **If** $V = vT/t = v(R/r)^{1/2}$, then the two bodies – with differing kinetic energies – are subject to an identical central acceleration.

Once again to conclude that also within gravity fields mass oscillation frequencies depend on the relevant kinetic energy, be it constant or variable. **Thus, clocks might be used in a comparative mode to assess also relative differential speeds with respect to the plenum.**

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

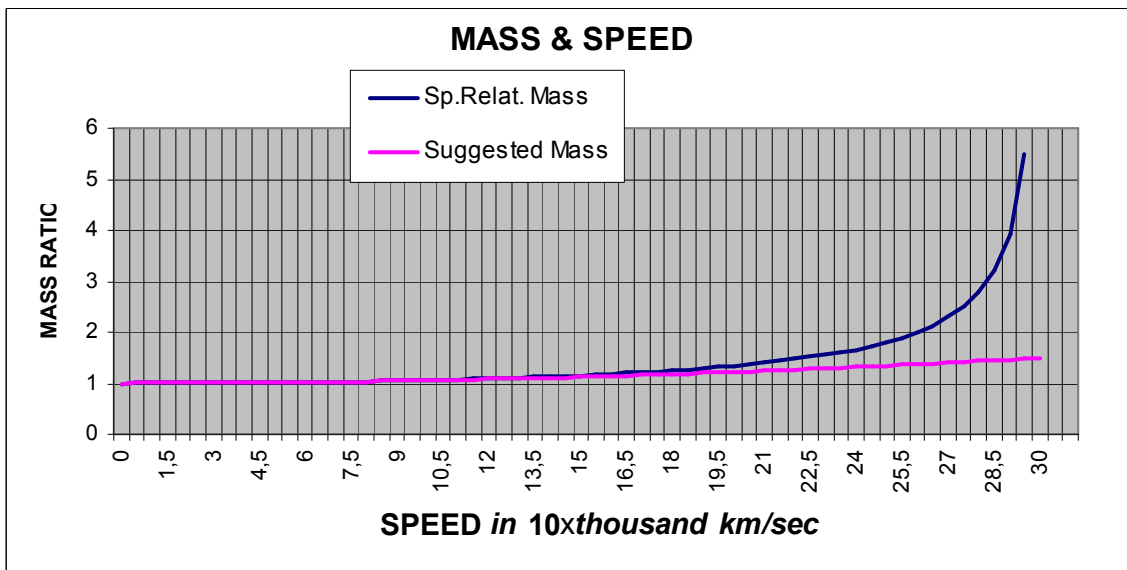
elements modifies under various dynamic conditions.²⁰ It must be said that much uncertainty prevails as to the conclusions to be drawn from the findings of those researches, because in no case one can neglect that any material object, in order to achieve any final speed, must first undergo acceleration. 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 intrinsically associated with any component of mass m). In such a case, the energy increment ΔE_m coincides actually with E_m . Considering [11] and [6a] above, in fact, the *active mass* (denote it as m_V ²¹) is given by

$$\Delta m_o = m_V = \frac{m_o}{2} \left(1 - \frac{\psi_V}{\psi_o}\right)^2 = \frac{m_o}{2} \left(\frac{V}{c}\right)^2, \quad [13]$$

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

$$m^* = m_V + m_o = m_o \left(1 + \frac{V^2}{2c^2}\right); \quad [14]$$



²⁰ 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.

²¹ It’s the mass that carries kinetic energy.

²² The graph above shows how mass ratio m^*/m_o expressed by this equation varies with speed, in a comparison with the variation relevant to the same mass ratio as per SR Equation [3]. Up to about $V \approx 0.60c$, 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 $m_c = 1.5m_o$.

As to physics, the “relativistic mass” seems senseless, and its definition conflicts with Equations [14] to [17] as these equations are also considered as achievements of Einstein’s special relativity. Actually, Equation [14] is an incidental hypothesis added by Einstein, whereas the same equation is here derived analytically. On this subject, see the comment in the next page.

and its *actual energy*, if $v_0 \cong 0$ (remember also relation [10]), is expressed by

$$\Delta E_m \equiv E_m = m_v c^2 \equiv \frac{m_0}{2} V^2 . \quad [15]$$

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], *though significant only if $V \leq c$* , do not exclude the theoretical possibility of a speed V that 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 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 $V \leq c$* , Equation [15] 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 logical way: consider Equation [14] after multiplication by c^2 , to write, because of [15],

$$m^* c^2 = (m_v + m_o) c^2 = m_o V^2 / 2 + m_o c^2, \quad [16]$$

which means that *the increment in the mass energy* indicated by Equation [15] can also be expressed as

$$\Delta E_m = m_o V^2 / 2 = m^* c^2 - m_o c^2, \quad [17]$$

if V is the mass speed *with respect to the plenum*. Therefore, Equation [17] above leads one to conclude inevitably that equation

$$E = m^* c^2 = m_o V^2 / 2 + m_o c^2 \quad [18]$$

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 ($E = m c^2$) is usually associated with Special Relativity, though the same equation - as heuristically shown by Einstein himself - can be obtained through more than one way of reasoning, to mean that it is not an achievement inherent in Special Relativity.

With reference also to **Footnote 22** of the preceding page, it must be observed - within the strict logic of Einstein's special relativity - that all inevitable implications of Equation [3] are incompatible with the conclusion showed by Equation [18]; unless additional as well as contradictory assumptions are introduced.

Before Einstein, Lorentz had formulated Equation [3] [i.e., $m = m_o (1 - V^2/c^2)^{-1/2}$] to define the relativistic “transverse mass”. Einstein came to the same definition in Paragraph 10 of his 1905 paper on special relativity. In that same paragraph of the paper, Einstein defined also the *kinetic energy* of an electron in motion by the following equation

$$E_K = m_o c^2 [(1 - \beta^2)^{-1/2} - 1] = (m - m_o) c^2, \quad [19]$$

in which $\beta^2 = V^2/c^2$, and m is the “relativistic transverse mass” recalled above.

Still in 1905, a few months after his paper on relativity, Einstein published another very short paper, “*Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig?*” (*Does the Inertia of a Body Depend upon its Energy Content?*), *Annalen der Physik*, Sept. 1905. In that

paper Einstein made his first attempt to propose the mass-energy equivalence. For the purpose, he introduced a drastic simplification by replacing Lorentz’s factor $1/(1-\beta^2)^{1/2}$ (where $\beta=V/c$) with the relevant series²³ cut at the second order term, thus assuming $1/(1-\beta^2)^{1/2} = 1+\beta^2/2$.

If the same simplification is allowed for in the relativistic definition of *transverse mass* used in Equation [19], Einstein’s relativistic definition of *kinetic energy* becomes

$$E_K' = m_0V^2/2 ,$$

which is only the classical definition of kinetic energy. Thus, Einstein’s Equation [19] would remain with no logical justification.

The preceding remarks lead me to the following conclusion:

- (a) If one considers the equation $E = mc^2$ as an experimentally well tested equation, then the Lorentz transformation factor $1/(1-\beta^2)^{1/2}$ involved by special relativity has no physical significance;
- (b) In an alternative, if one considers the Lorentz factor as the basic achievement of special relativity, then this theory cannot be credited with the rigorous achievement of the mass-energy equivalence equation expressed by $E = mc^2$, which shall instead be viewed as a separate hypothesis formulated in various ways both by Einstein and by some of his predecessors. Such a hypothesis, however, does certainly conflict with the *logical paradigm* of Einstein’s special relativity.

(v) The “spacetime”

In 1907, the advent of the “spacetime”, with Poincaré-Minkowski-Tolman interpretation of Lorentz’s relativity, had created quite a new theoretical situation, in which every previous hypothesis or intuition stating the mass-energy equivalence could transform *naturally* into one of the *axioms* of the new paradigm. The traditional Euclidean three-dimension space that physics uses in association with “time” to describe phenomena, is transformed by the *spacetime* into a *quasi-Euclidean four-dimension space* where “time” is a fourth additional linear dimension (represented by product $c \cdot t$) **measurable in length units**, homogeneous to the other conventional three dimensions.

In the *spacetime* the “physical dimensions”, i.e., the intrinsic characteristics of physical quantities undergo a dramatic change. For example, “speed”, whose “physical dimension” is conventionally the *ratio of a length to a time*, in the spacetime becomes *the ratio of a length to a length*, which means a *pure number*; thus, speed is no more a *physical* quantity, since it has no *physical dimension*. Therefore, in such a formal context the concept of “**energy**”, which is conventionally thought of as *a mass multiplied by a square speed*, turns into the concept of *a numerical multiple of a mass* (in the same sense as one can state - for example - that two tons are two thousand times one kilogram).

Analogously, also the *physical dimension* of “**momentum**” is equivalent to the dimension of “mass”. In simpler words, in the spacetime “energy”, “momentum” and “mass” become automatically nothing more than three different terms for identifying one same *type* of physical quantity, the *mass*, in three different states, two of which (mass, energy) are *scalar* quantities and one (momentum) is a *vector* quantity. It is also a way to state that in the spacetime the three traditional physical dimensions *Length, Time* and *Mass* coagulate in the dimensional

²³ The ratio $1/(1-\beta^2)^{1/2}$ can be expressed by the series $1 + \beta^2/2 + 3\beta^4/8 + \dots + 1 \cdot 3 \cdot 5 \cdot \dots \cdot (2n-1)\beta^{2n}/(2 \cdot 4 \cdot 6 \cdot \dots \cdot 2n)$, in which $n \rightarrow \infty$.

couple of *Length* and *Mass* only. Nevertheless, it is worth pointing out that while “speed” is a scalar quantity also in the spacetime, “velocity” becomes a vector quantity, which is endowed with a direction that affects any mass in motion in determining the relevant vector momentum.

Of some interest is also considering that in Minkowski’s spacetime the physical dimension of *acceleration*, and in particular of a *central acceleration* too, is the inverse of a “length”, i.e., the dimension of a “curvature”.

(vi) Superluminal motion ²⁴

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 theories, even against the evidence provided by very significant observations, which should instead induce scientists to doubt what they are used to believe.

At least since 1981,²⁵ in observing the *strange* very long linear flares, or “jets” orthogonal to galaxy disks and currently associated with the activity of the galactic nuclei, 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 given explanations do actually limit to 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 insufficient. 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* of *Vacuum, Vortices and Gravitation*, the observed superluminal motions can naturally be explained with respect to the *true vacuum* (or 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

²⁴ Since a few decades some articles and essays try to question 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.

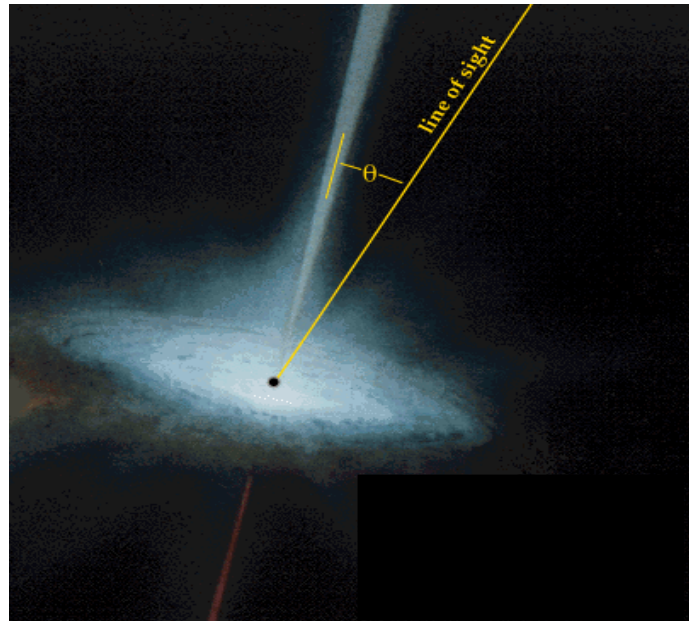
It is not my intention to avail myself of such a topic: in my view, most of the discussion on the subject does either focus on a false problem (“locality”/ “non-locality” of our universe) or draw arbitrary conclusions.

Besides, 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.

²⁵ 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* **28**, April 1983, and R. J. Davis, S. C. Unwin, T. W. B. Muxlow, *Large scale superluminal motion in the Quasar 3C273*, *Nature* **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.

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 hypothesized *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 with 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 diameter of the “spherical vortex” into which the ring-vortex transforms when moving across the plenum.