ISSN: 2754-4753

Journal of Physics & Optics Sciences

SCIENTIFIC Research and Community

Research Article

Open Access

Uniform Scaling of Physical Units and the Principle of Rationality of Measurement

Robert J. Buenker

Fachbereich C-Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, Gaussstr. 20, D-42119 Wuppertal, Germany

ABSTRACT

One of the most basic principles in science is the objectivity of measurement of physical properties. According to the special theory of relativity (STR), this ancient principle is violated for observers in relative motion since it predicts that they generally will disagree on the *ratios* of the lengths of two objects and also on whose clock is running slower at any given time. Both predictions stem from the Lorentz transformation (LT), which is the centerpiece of Einstein's STR. It has recently been pointed out that two of the claims of this theory are mutually contradictory; it is impossible that the rates of two clocks in motion are strictly proportional to one another (time dilation) while one of them finds that two events are simultaneous whereas the other does not (remote non-simultaneity). This recognition proves that the LT is not a valid component of the relativistic theory of motion, including its well-known thesis that space and time are not distinct quantities. Instead, it has always been found experimentally that the rates of clocks in motion are governed by a Universal Time-dilation Law (UTDL), whereby the speed of the clock relative to a specific rest system is the sole determining factor. A simple way of describing this state of affairs is to say that the standard unit of time in each rest frame is different and increases with its relative speed to the above rest system by a definite factor. The measurement process is thereby rendered to be completely objective in nature. A key goal of relativity theory is therefore to develop a quantitatively valid method for determining this factor. It will be shown that the same factor appears in the true relativistic space-time transformation and that it also plays a key role in the uniform scaling of all other physical properties.

***Corresponding author**

Robert J. Buenker, Fachbereich C-Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, Gaussstr. 20, D-42119 Wuppertal, Germany; E-Mail: bobwtal@yahoo.de

Received: July 08, 2021; **Accepted:** July 16, 2021; **Published:** July 25, 2021

Keywords: Uniform Co-Ordinate Scaling, Universal Time-Dilation Law (UTDL), Objective Rest Frame (ORS), Absolute Simultaneity, Principle of the Rationality of Measurement (PRM)

Introduction

One of the most interesting aspects of the history of civilization was the development of a system of weights and measures. In order to have fair trading practices, it was very important for different groups to agree on standards of length and weight and other quantities. Although this ideal has actually not been realized even to the present day, it still was possible to carry out business transactions in a relatively peaceful manner because a basic principle was recognized that is referred to below as the *rationality of measurement*. The idea was quite simple to apply once one had grasped how to carry out basic arithmetical operations. The key point is that after one defines *a standard unit* for a given physical property, it is possible to assign a unique numerical value for the amount of this property to be associated with any conceivable object. If two traders used a different unit, which was often the case, it was only necessary to know the ratio of these two units in order to compare their measurements for a given quantity, that is, convert one numerical value to that in another system of units.

When Einstein introduced his special theory of relativity (STR), he broke with tradition and did not require that the Principle of the Rationality of Measurement (PRM) be valid for observers in different inertial systems [1]. This is due primarily to the inclusion of the Fitzgerald-Lorentz contraction effect (FLC) in this theoretical framework. For example, according to STR the ratios of the lengths of two sides of a given triangle are generally different for two such observers in relative motion to one another. This state of affairs is ruled out by the PRM. It is important to see, however, that the FLC has never been confirmed in actual experiments, even though the literature is replete with Gedanken Experiments that are consistent with it [2].

There is a more general feature of STR that also violates the PRM, however, namely the claim that measurement is *symmetric* for observers in relative motion to one another [1, 3]. Accordingly, it is claimed that two clocks can both be running slower than one another at the same time and also that the above contraction effect is just a matter of the perspective of each of the observers. After all, it is argued, two such observers each have the perception that it is the other that is moving. On this basis it is claimed that it is only natural that each one will think it is the other's clocks that are running slower or the other's measuring rods that are contracted, not his own. This also means that the observers cannot agree on *the ratios* of elapsed times of a given pair of events when they occur in different inertial systems. The same holds true for distances between objects in different inertial systems. As a result, all of these conclusions of STR are seen to be in direct conflict with the PRM.

It is generally claimed that the rest of Einstein's theory is so firmly established that one must therefore accept all of its predictions as facts even in the complete absence of experimental verification [1]. This conclusion is challenged in the discussion below. It will be shown that it is possible to satisfy Einstein's two postulates of relativity theory, the relativity principle (RP) and the constancy of the speed of light in free space, without coming into conflict with the PRM.

Universal Time-Dilation Law (UTDL)

Experiments that were carried out with atomic clocks located on circumnavigating airplanes found that the rate of a given clock was determined exclusively by its speed v relative to the earth's center of mass (ECM), or "non-rotating polar axis" as the authors phrased it [4-5]. If one defines the elapsed time for a given portion of the flight that is measured on a hypothetical clock located at the ECM as Δt (ECM), the corresponding elapsed time for a clock moving at speed v relative to the ECM was recorded to be [5]:

$$\Delta t = \frac{\Delta t(\mathrm{ECM})}{\gamma(v)} \qquad (1)$$

In this equation $\gamma(v) = (1-v^2c^{-2})^{-0.5}$, where c is the speed of light (299792458 ms^{-1}). In actuality, the authors only employed eq. (1) to first-order in $(v/c)^2$, i.e. with $\gamma(v) \approx 1+0.5v^2c^{-2}$. By applying this equation to any other clock moving with a different speed v' relative to the ECM, it is possible to eliminate Δt (ECM) to obtain a general relation that is applicable for any pairs of such clocks:

$$\Delta t\gamma(v) = \Delta t'\gamma(v') \qquad (2)$$

The above equation is also applicable for the results of a different series of experiments carried out with an x-ray source and absorber mounted on a rotating disk. In this case, the elapsed times Δt and Δt' are replaced by the frequencies ν and ν' of the x-ray source and absorber [6-8]. Again, the authors made use of the first-order approximation for γ in comparing their results. The corresponding speeds are taken relative to the rest frame of the rotor axis. Accordingly, it was found that the "clock" with the higher relative speed always has the lower frequency [7]. A key aspect of eq. (2) is that the speeds must be computed relative to a specific rest frame, which has been referred to in earlier work as the *objective rest frame* (ORS) [9]. It is the rotor axis in the x-ray study, whereas it is the ECM in the circumnavigating atomic clock experiment. More generally, it is the rest frame in which a force has been applied which causes an object to be accelerated to a given speed. A situation of this type is discussed in Einstein's original work [1]. He also claimed in the same paper that a clock at the Equator would run slower than one as the earth's Poles, in which case the ECM is again the ORS. His conclusion is quantitatively consistent with eq. (2). For all these reasons, it is reasonable to refer to it as the Universal Time-dilation Law (UTDL) [10-12]. The UTDL is easily generalized to the case where the two objects have different ORS from which the respective relative speeds are to be determined.

The experimental data that form the basis for the UTDL indicate unequivocally that it's always possible to know, at least in principle, which of two clocks is running slower. This can be seen most clearly by computing the ratio Q of elapsed times from eq. (2):

$$Q=\Delta t/\Delta t'=\gamma(v')/\gamma(v). \qquad (3)$$

This relation shows that the clock moving with the greater speed relative to its ORS will always record a smaller elapsed time separating two events, i.e. will be running slower than its counterpart, completely independent of the two events under consideration. Thus, according to the UTDL, *timing measurements are perfectly objective in character*. There is no hint of the subjectivity which is predicted by the LT, whereby each observer supposedly thinks that the stationary clock in his rest frame is running faster than the corresponding one in the other's rest frame. *The UTDL takes the observer out of the measurement process*. It makes no difference what unit of time a given observer uses to make this comparison. In all cases the ratio of the two elapsed times will be the same because it only depends on the speeds of the clocks relative to a particular rest frame, i.e. the ORS, and is therefore completely independent of the relative speed of the observers themselves.

Variation of the Unit of Time with Motion

The symmetry of Einsteinean time dilation makes it impossible to know whether clocks run slower in one rest frame or another. According to this theory, depending on which observer makes the determination, clock A might be considered to run faster than clock B or vice-versa. Experiment in the form of the UTDL of eq. (2) indicates by contrast that it is always possible in principle which of two clocks runs slower. Moreover, the ratio of the two clock rates can be accurately predicted as well. In this case it is also possible to speak of having a specific unit of time in each rest frame. For example, the unit of time in the rest frame of the ECM can be taken to be 1.0 s. A clock moving with speed v therefore has the corresponding unit of γ (v) s [13]. Thus, an event which takes place in Δt (ECM) s based on the stationary hypothetical ECM clock will occur in less time based on the above clock moving with speed v relative to the ECM, namely in γ^{-1} Δt (ECM) s (γ>1). In other words, since the latter unit of time is γ times greater, the corresponding numerical value is γ times less than on the ECM clock.

Defining the second in terms of a hypothetical clock located at the ECM is certainly not a very practical idea. In addition, there are many other planets and stars that one might choose for the same distinction as the rest frame in which the second is defined [14]. There is a more important reason for not taking such an approach, however. Because of the relativity principle (RP), it is natural to always define the second in terms of a stationary clock *in one's own rest frame*, which of course means that there must be an infinite number of distinct definitions of this unit.

The concept of a unit of time in each rest frame is still of practical value, however, because of eq. (3). The quantity Q therein serves as a *conversion factor* between different units. It allows one to calculate the value of a time difference in one rest frame based on the corresponding value in another. For example, if the value in rest frame S' is Δt', it follows that the corresponding value measured on the stationary clock in S is Q times larger, i.e. Q Δt' [assuming that v'>v in the UTDL of eq. (2)]. As a consequence, it is possible to carry out such timing measurements with a stationary clock in any rest frame and then use the appropriate conversion factor to obtain the value in one's own system of units. This approach turns out to be of great utility in the GPS navigation system. The time at which an event occurs on a satellite is converted to the corresponding value on the earth's surface with the help of a conversion factor that is computed using eq. (1).

When the tables are turned and the observer in S makes the measurement, the corresponding conversion factor Q' is obtained by exchanging the primed and unprimed quantities in eq. (3). The result is:

$$Q'=\Delta t'/\Delta t=\gamma(v)/\gamma(v') = 1/Q, \qquad (4)$$

i.e. the inverse conversion factor is just the reciprocal of the original. This relationship is completely analogous to what one has in conventional unit conversions. For example, the factor in going from m to cm is 100, whereas the corresponding factor from cm to m is 1/100.

The concept of a standard rest frame from which to base the unit of time for all other rest frames is nonetheless a promising one. One can imagine a unique rest frame Ω in the universe in which the rates of stationary clocks are at a maximum. The rates of proper clocks anywhere else in the universe can be defined to be α_i times slower, where αi will be referred to as its clock-rate parameter. In analogy to eq. (1), the elapsed time measured for a given event on the Ω clock is assumed to be Δt (Ω). The corresponding time recorded on a stationary clock in an ORS with a clock-rate parameter of αORS is $\Delta t\ (\Omega)(\alpha ORS)^{-1}$. A clock which is moving with speed v relative to the ORS will therefore measure a smaller value of

$$\Delta t= \Delta t\ (\Omega)[\gamma(v)\alpha_{ORS}]^{-1}, \qquad (5)$$

which value is to be inserted in the left-hand side of the UTDL of eq. (2). The corresponding elapsed time measured on a second clock moving with speed v' relative to ORS' is accordingly

$$\Delta t'= \Delta t\ (\Omega)[\ \gamma(v')\alpha_{ORS'}]^{-1}. \qquad (6)$$

Combining the above two equations then leads to the relation given below:

$$\alpha_{ORS}\ \Delta t\gamma(v)= \alpha_{ORS'}\ \Delta t'\gamma(v') \qquad (7)$$

If the two ORSs are the same, eq. (7) clearly reduces to the UTDL of eq. (2). If they are different, but the ratio of the rates of the ORS and ORS' clocks is known, it is then possible to derive a generalized form of the UTDL. For example, the ORS might be the rest frame of the ECM, whereas ORS' could be the rest frame of the moon. The speed of the center of mass of the moon v_M relative to the ECM can then be used to evaluate the αORS'/αORS ratio as $\gamma\ (v_M)$, so that eq. (7) becomes:

$$\Delta t\gamma(v)= \Delta t'\gamma(v_M)\ \gamma(v') \qquad (8)$$

It should be noted that the above equation has been derived by assuming that there is a definite rest frame Ω located somewhere in the universe whose stationary clocks run at the maximum possible rate. This characteristic is not essential for the derivation, however. If one employs a clock which is stationary in a rest frame X whose clocks run slower than those in the above hypothetical rest frame by a factor of β>1, this would mean that both of the αORS' and αORS factors would be multiplied by 1/β in the corresponding derivation. As a result, one would also obtain eq. (8) using the standard rest frame X as well. This fact is clearly a consequence of the rationality of measurement mentioned in the Introduction, which has been assumed throughout this discussion. This is a key difference between the present theory of relativity and that espoused by Einstein over a century earlier [1].

Before closing this discussion, it is well to note that the UTDL of eq. (2) assumes that both timing measurements are carried out at the same gravitational potential. If this is not the case, it is simply necessary to make a correction (gravitational red shift) for the elapsed time Δt' (S) obtained employing the clock located at one potential to convert it to the value in the units of the (standard) rest frame. For example, Einstein showed that $S=1+ghc^{-2}>1$ for a clock located at a higher position h in a field with gravitational acceleration g. The corresponding corrected elapsed time is accordingly equal to Δt'= Δt' (S)/S, and this value can then be substituted in eq. (2) to obtain the value of Δt. More detailed discussion of gravitational corrections of elapsed times is given elsewhere [17-18].

Variation of Other Physical Units with Motion

The question that will be discussed in the present section is whether the above theory for clock rates and elapsed times can be extended to other physical properties. The answer needs to be sought with reference to well accepted experimental results. A good place to start is with velocities. Einstein's second postulate is predicated on the results of numerous experiments which indicate that the speed of light is independent of its light source [1]. On this basis one must conclude that the unit of velocity/speed is constant. Otherwise, each observer would potentially obtain a different value for the speed of light in free space, just as they are known to obtain different elapsed time values for the same event. The relativistic velocity transformation (VT) leads to a related conclusion that all *relative* velocities, that is, velocities between two moving objects, are the same for all observers independent of their state of motion [19].

The above conclusion has definite consequences for the unit of distance/length, however. It must vary in exactly the same proportion as elapsed times in order to be consistent with the constancy of the unit of velocity, i.e. it must also vary as Q. Moreover, the unit of distance must be independent of direction since relative velocities are also the same in all directions according to the VT [19]. This means that isotropic length expansion accompanies time dilation. In other words, when the unit of time increases, *the corresponding value of the unit of distance such as the wavelength of a standard atomic line must increase by exactly the same fraction*. This is exactly what is found in the Ives-Stilwell experiment, namely the wavelength of light emanating from an accelerated light source, with Q=γ(v)>1 according to eq. (3) and the UTDL of eq. (2), is measured in the laboratory to be *greater* than the standard value (obtained when the source is at rest) by the same factor Q (within experimental error) [20-21].

The prediction of isotropic length expansion accompanying proportional time dilation stands in stark contrast to the widely accepted STR claim regarding the variation of lengths of objects with their state of motion. In that view, lengths should contract, and by varying amounts depending on their orientation to the observer, as the object is accelerated. This prediction of Einstein's theory has come to be known as FitzGerald-Lorentz length contraction (FLC), named after its originators in the late 19th century [22-23]. Various authors have reported supposed confirmation of the FLC but they have invariably confused it with a different phenomenon which is quite well established, namely de Broglie wave-particle duality [24-26]. The latter is a law of physics for large ensembles of particles, according to which the wavelength λ of their distribution in space is inversely proportional to the particle momentum p (p=h/λ). The manner in which the wavelength varies with speed is quite different from the way that distance and relative speed vary in the FLC [27] however, and so it is easy to show that the experimental data in fact are not at all quantitatively consistent with the FLC [24-25].

The experiment carried out by Bucherer in 1909 in which the inertial mass m of accelerated electrons was found to increase with their speed in the laboratory is also quite important in this context [28]. It was found that m increases in exactly the same proportion as the periods of accelerated clocks, namely as γ (v). On this basis one can safely conclude that the unit of inertial mass also varies as Q.

If one continues to assume that the measurement is completely objective, it becomes easily possible to determine conversion factors for any conceivable physical property. One merely needs to know the composition of the property in terms of the standard units of distance, inertial mass and time (as in the mks system) to compute the appropriate conversion factor in a unique manner. For example, angular momentum l is a product of inertial mass, speed and distance (mvr). Since both m and r vary as Q and v is constant, it follows that the unit of l varies as $QxQxQ^0= Q^2$. As a result, one can conclude that Planck's constant h also varies as Q^2 with the speed of the radiation source. This result is therefore consistent with Planck's famed radiation law E=hν, since energy E scales as Q (since it is the product of inertial mass and the square of the speed), while the frequency ν is the reciprocal of the period of the radiation and therefore scales as Q^{-1} [29]. More details concerning the scaling of physical units may be found elsewhere [30]. It is even possible to take advantage of a degree of freedom in the definition of the units of electricity and magnetism to devise a related scheme for the scaling of these quantities with the motion of charged particles [31].

High-Speed Travel and the Relativity Principle

The experiments that have led to the establishment of the UTDL of eq. (3) have involved relatively small velocities relative to a pertinent rest frame, such as the ECM (ORS) in the case of the Hafele-Keating study [4, 5]. What happens when the speeds are much higher, for example, approaching the speed of light? If one accepts the UTDL as having completely general validity, it would seem that all one has to do to obtain a concrete description of the circumstances that would confront such a high-speed traveler is to apply this formula for correspondingly large γ (v) quantities.

From the standpoint of his stationary counterpart (O) located in the ORS from which he (O') departed, his *in situ* clocks run much slower than before, the inertial masses of all the objects co-moving with him are much larger, and the distances separating them on his spacecraft are now much greater as well. Yet, the Relativity Principle (RP) demands that O' be unable to detect any of these changes with his local measuring devices.

There is no restriction on the value of γ so long as it is positive and finite (v<c). Suppose that his speed is 0.8 c relative to the ORS. Then the value $Q = \gamma (v) = (1-v^2c^{-2})^{-0.5}$ would be 5/3. Without worrying about such important details as to how the necessary measurements could be carried out with sufficient accuracy, O would find that a laser beam of standard frequency ν emitted from O's rest frame would only have a value of 0.6 ν, that is, after correcting for any Doppler effect that might occur. The corresponding wavelength would be 5/3 larger than the standard λ value. All of this is consistent with the Ives-Stilwell experiment [20, 21]. The speed of light would still have the standard value of c on this basis for both O and O'. Independent measurements by O' on his spacecraft, by contrast, would find that the *in situ* wavelength and frequency of the emitted laser beam had the standard values.

There is no need to stop at a value of Q= γ= 5/3. How would things look if $Q=\gamma=10^9$? First of all, O back on the earth would find that the dimensions of the spacecraft had increased enormously. Its volume would now be 10^{27} times larger than when it departed. This raises a question, however. What if the distance to the midpoint of the spacecraft is smaller than its new radius? The obvious answer is that there would be an overlap between the position of O and the spacecraft, which would translate into a collision between them. One has to realize something about the mass/energy of the spacecraft, however. The new energy of the spacecraft would be 10^9 times greater than when it started on its journey. Where would that energy come from? There is only so much energy to go around, which puts a clear limitation on how large a speed could possibly be attained by the spacecraft. In short, the dilemma posed by these distance values is of no practical consequence. Without doing any actual calculations, it seems fair to say that it is impossible to so strongly increase the speed of such an object so that the aforementioned overlap can actually occur in practice.

There is nonetheless merit in considering how the situation would appear from the vantage point of a high-speed observer (O'). According to the RP, he would not be able to notice any difference in measurements of co-moving objects. The situation is identical to that considered by Galileo with his model of a ship moving on a perfectly calm sea. Another observer O at rest on the earth's surface would be able, in principle at least, to detect enormous changes in the objects located on the spacecraft. If $Q=\gamma=1.0x10^9$, for example, when O' measures an elapsed time of 1 s for a given event, O would find according to the UTDL a corresponding value of 1 billion s. Also, a metal bar of 1.0 m length on the spacecraft would be measured by O to have a length of 1 billion m.

This means that when O' measures distances anywhere in the universe, he would be comparing them to the above metal bar as standard. Consequently, the whole universe would appear to *shrink for him* to one-billionth of the normal size perceived by earthbound observers. For example, the distance between the earth and the sun would be measured by O' to be a mere 150 m. It is important to understand that O' would actually measure this value by comparing the distance to some standard wavelength of radiation emitted onboard the spacecraft. The 150 m distance would be indistinguishable from the length of a 150 m object located in this rest frame.

So how large is the distance to the sun in reality? Is it 150 m as O' finds or $1.5x10^{11}$ m as we know on earth? One can say, somewhat provocatively, that both values are correct. The reason that is true is because a meter for O' is not the same a meter for O. It would be better to distinguish between the two units, denoting 1.0 m on the spacecraft as 1.0 m*, where the latter distance is actually one billion m in the units of the earthbound observer. The value of $1.0x10^9$ is simply a conversion factor between the two units. *A good rule to follow in this context is that the numerical value of any quantity is inversely proportional to the size of the unit in which it is expressed*. The situation is no different than if the distance between two cities is expressed in both mi and km. The value is different in the two cases, but all one needs is the standard conversion factor between mi and km to eliminate any confusion about what the real distance is. The problem in relativity is that both of the observers believe that they are using the standard value of a meter to express their measurements. The RP simply states that there is no way either one of them can distinguish their "meter" from the other based on their respective *in situ* measurements.

The shrinking of the universe for the passenger on the spacecraft is not an illusion, however. It is a real effect that is the inevitable conclusion that follows from consideration of the experimental elapsed time data summarized by the UTDL on the one hand, and the light-speed constancy postulate underpinning the GPS-LT on the other. It is interesting to see the connection between fact and fiction in this case. Lewis Carroll anticipated just such an effect in "Alice and Wonderland." The protagonist drinks a magic potion and finds that the characters and objects around her have all suddenly become uniformly much smaller. In real life the potion is the extreme degree of acceleration experienced by the passenger. The fiction departs from reality in the main only because it depicts a situation in which Alice and the miniature characters are all stationary in the same rest frame. By contrast, the effect indicated by actual experiments can only occur if Alice is moving away from her original position at an extremely high speed. What Carroll imagines is thus just a "snapshot" of Alice and her perception of the surroundings as she is whisked through space into the far unknown.

The situation with comparative elapsed times remains to be discussed. If the clocks on the spacecraft run $Q=1.0\text{x}10^9$ times slower than on the earth's surface, it follows that the time for light to pass from the sun to the earth would only be $0.5\text{x}10^{-6}$ s instead of the usual value observed on earth of 500 s. Moreover, the time the known universe has been in existence would only be 14 yr for the passenger on the spacecraft instead of the 14 billion years estimated by experimental studies on the earth. Does this mean that the passenger could easily *outlive* the history of the universe to date? This is a statement of what is known as the "Twin Paradox." It was the stated objective of the Hafele-Keating study with circumnavigating airplanes to investigate this very question [4, 5].

The answer is completely analogous to that already considered for distances. Each of the above events actually takes place over an identical time span for the two observers. The reason they obtain different values in each case is simply that they employ by definition different units of time in expressing their findings. *The supposed retardation of the aging process caused by high-speed travel is simply a myth*. It ignores the basic rationale of the RP that says that the two observers are subject to the same laws of physics. If the spacecraft undergoes completely uniform motion, it is also free of unbalanced external forces. There is consequently no reason that the aging process is any different there than on the earth's surface. In other words, changing the rates of clocks does not in any way affect how long we live, whether done manually in one's kitchen or occurring automatically on a hyper-speed rocket in accord with the UTDL. When the twins come back together, they simply find that the elapsed time on their clocks is quite different but that there is no recognizable change in their age difference. Moreover, the UTDL could be used to predict the time differential shown on their clocks by taking account of the speed trajectory of the spacecraft.

Conclusion

When an object is accelerated, there is a change in its physical properties. This conclusion is based first and foremost on experiments carried out to study the effect on the rates of clocks as they change their state of motion. The Hafele-Keating study is probably the most direct demonstration of this general state of affairs [4, 5]. Their results were also completely consistent with x-ray frequency measurements reported a decade earlier by Hay et al. and other authors [6-8]. The next step in the argument is to simply accept Einstein's second postulate of the constancy of the speed of light in free space relative to its source [1]. If one believes that measurement is a completely objective process, it follows that the slowing down of clocks, and therefore of their periods, must have been accompanied by a compensatory *increase* in the lengths of objects *traveling with the clocks* that could be used to measure distances *anywhere outside the spacecraft*. Moreover, *the proportion of increase* must have been the same in all directions (isotropic length expansion) because the speed of light is also the same in all directions. In that way, both a smaller elapsed time and a *shorter* distance would be measured by the observer moving with these objects, so that no change in the speed of light in any direction occurs based on his *in situ* measurements.

In addition to clocks slowing down and lengths of objects increasing, it is to be expected that the inertial masses of these objects will also increase in the same proportion. This is because of the observations by Bucherer of increased mass of electrons when they are accelerated in the laboratory [28]. Once one knows how the units of time, distance and inertial mass vary, it follows that the changes in other physical properties can be obtained accurately simply by noting their composition in terms of these fundamental quantities. This means, for example, that frequencies should decrease by the same fraction as the periods of atomic lines increase. Also that angular momentum should change faster than either radial distances or inertial masses because it depends on both quantities.

In recognition of the above relationships, a basic goal of relativity theory is therefore to allow for a quantitative prediction of these changes in properties. The standard theory of relativity certainly takes on this responsibility, but it fails to obtain a satisfactory resolution of the matter because of its reliance on the Lorentz transformation and its cardinal belief in the inseparability of space and time. This deficiency shows up first and foremost in the theory's claim that the speed of an object needs to be determined relative to the observer's position in space. Einstein's approach demands, for example, that two observers can disagree in principle about which of two clocks is running slower, or which of two masses is larger, or which of two distances is shorter. This is the inevitable consequence of belief in the Lorentz transformation. Accordingly, *the observer becomes an active participant in the measuring process*, making it entirely *subjective* in character.

The studies of the rates of atomic clocks on circumnavigating airplanes and the frequencies of x-ray detectors and sources mounted on a high-speed rotor tell a much different story, however [4-8]. They indicate that there is always a specific rest frame (objective rest system or ORS) from which to compute the speeds of objects [9]. It is the ECM in the former study and the axis of the rotor in the latter. In other cases, the ORS is the rest frame from which the object is initially accelerated. Einstein did come to the latter conclusion in his discussion of an electron travelling in a circular path, but he treated that case as being completely inapplicable to freely translating systems [1]. Instead, he put his complete trust in the Lorentz transformation to deal with such "inertial" objects.

The above experiments underscore the importance of the function $\gamma(v)=(1-v^2c^{-2})^{-0.5}$ which commonly occurs in relativity theory, where v is the speed of a given object such as an atomic clock relative to its ORS [4-8]. They show that the elapsed time Δt measured for an event is inversely proportional to $\gamma(v)$. This relationship, as expressed in eq. (2), also holds for the rotor experiments done earlier, and so it is appropriate to refer to it as the Universal Time-dilation Law (UTDL). It is easily extended to the even more general case of eq. (8) when the ORS is different for the two clocks. As a consequence, it is possible to relate the value of an elapsed time measured by a clock in any given rest frame in the universe to the corresponding value that would be measured in any other rest frame. The conversion factor Q between the rates two clocks is simply obtained as a ratio of two or more γ factors, as for example is shown in eq. (3) for the case of equal ORSs. The same factor appears explicitly in the Newton-Voigt transformation (NVT), which replaces the Lorentz transformation in the revised theory. There is also a corresponding factor (S) that takes account of differences in the gravitational potentials of the two clocks, as discussed elsewhere [17-19]. Moreover, once Q and S are known, it is also easily possible to obtain the conversion factors for any other conceivable physical property since the latter are always integral powers of Q and S, respectively. The revised theory enables one to hold fast to the ancient principle of the rationality of measurement (PRM) which states that all observers must agree on the ratio of any two measured quantities, independent of the unit in which they express their respective findings [33].

References

1. A Einstein (1905) "Zur Elektrodynamik bewegter Körper," Ann. Physik 322: 891.
2. EF Taylor, JA Wheeler (1966) Spacetime Physics (W. H. Freeman and Company, San Francisco, 1966).
3. H Goldstein (1950) Classical Mechanics (Addison-Wesley Publishing Co., Reading, Massachusetts) 193-p.
4. JC Hafele, RE Keating (1972) "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains," Science 177: 166.
5. JC Hafele, RE Keating (1972) "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains Science," Science 177: 168.
6. HJ Hay, JP Schiffer, TE Cranshaw, PA Egelstaff (1960) "Measurement of the Gravitational Red Shift Using the Mössbauer Effect in Fe57," Phys. Rev. Letters 4: 165.
7. W Kündig (1963) "Measurement of the Transverse Doppler Effect in an Accelerated System," Phys. Rev 129: 2371.
8. DC Champeney, GR Isaak, AM Khan (1963) "Measurement of Relativistic Time Dilatation using the Mössbauer Effect," Nature 198: 1186.
9. RJ Buenker (2010) "Time dilation and the concept of an objective rest system," Apeiron 17: 99.
10. RJ Buenker (2012) "The sign of the Doppler shift in ultracentrifuge experiments," Apeiron 19: 218.
11. RJ Buenker (2014) Relativity Contradictions Unveiled: Kinematics, Gravity and Light Refraction, Apeiron, Montreal 50-p.
12. RJ Buenker (2016) "The lack of internal consistency of the Lorentz transformation and its consequences for the concept of space-time mixing," J. App. Fundamental Sci 2: 1.
13. RD Sard (1970) Relativistic Mechanics, W. A. Benjamin, New York 95-p.
14. TE Phipps Jr (2006) Old Physics for New, Apeiron, Montreal 127-p.
15. CM Will (1993) Was Einstein Right?: Putting General Relativity to the Test. 2nd ed., Basic Books Inc; New York 272-p.
16. T Van Flandern (1998) in: Open Questions in Relativistic Physics, ed. F. Selleri, Apeiron, Montreal 81-p.
17. RJ Buenker (2008) "Gravitational and kinetic scaling of physical units," Apeiron 15: 382.
18. RJ Buenker (2015) "The equivalence principle and uniform coordinate scaling," Open Sci. J. Mod. Phys 2: 32.
19. RJ Buenker (2016) "On the equality of relative velocities between two objects for observers in different rest frames," Apeiron 20: 73.
20. HE Ives, GR Stilwell (1938) "An experimental study of the rate of a moving clock," J. Opt. Soc. Am 28: 215.
21. HI Mandelberg, L Witten (1962) "Experimental verfication of the relativistic Doppler effect," J. Opt. Soc. Am 52: 529.
22. GF Fitzgerald (1889) "The Ether and the Earth's Atmosphere," Science 13: 390.
23. HA Lorentz (1892-1893) "The Relative Motion of the Earth and the Ether." Royal Academy of Sciences in Amsterdam. Clear Physics Department. Reports of the Sessions 1: 74; P Zeeman, AD Fokker (1935-1939) eds., Collected Papers, Nijhoff ,The Hague 4: 219-223.
24. A Laub, T Doderer, SG Lachenmann, RP Huebner, VA Oboznov (1995) Phys. Rev. Letters 75: 1372.
25. http://en.wikipedia.org/wiki/Length_contraction
26. L. de Broglie (1923) "RADIATION - Waves and Quanta" Compt. Ren 177: 507-510.
27. RJ Buenker (2013) "The Myth of FitzGerald-Lorentz Length Contraction and the Reality of Einstein's Velocity Transformation," Apeiron 20: 27.
28. AH Bucherer (1908) Phys. Zeit. 9: 755.
29. RJ Buenker (2014) Relativity Contradictions Unveiled: Kinematics, Gravity and Light Refraction, Apeiron, Montreal 74-p.
30. RJ Buenker (2014) Relativity Contradictions Unveiled: Kinematics, Gravity and Light Refraction, Apeiron, Montreal 71-77-p.
31. RJ Buenker (2015) "Expressing the units of electricity and magnetism directly in the mks system," J. Found. and Applic. Phys 2: 11.
32. RJ Buenker (2019) "The Newton-Voigt Transformation," J. Sci. Discov 3: 1-8.
33. RJ Buenker (2021) "Relativity theory and the principle of the rationality of measurement," Int. J. App. Math. & Stat. Sci. 10: 1-12.