Chapter 2

LORENTZ-INVARIANT UNIVERSAL TIME

The circular arc swept out by the angular displacement of a clock indicator (or its equivalent representation) measuring time is shown to be a Lorentz invariant, representing "universal" time. The concepts of time dilation and transverse Doppler effect are accordingly not physically observable. Length contraction, also experimentally unconfirmed, and kinematic temporal phase, both consequences of the Lorentz transformations, are also physically unobservable. The unobservability of these "effects," due to Lorentz-invariant "universal" time, renders the Lorentz transformations kinematically trivial and untenable.

There are several experiments that purport to confirm time dilation as a "kinematic" consequence of *uniform translatory* motion. The experimental evidence for time dilation, when examined critically, will be shown, in Chapter 6, to be inconclusive. There are certain heretofore unnoticed theoretical aspects imposed as consequences of the Lorentz transformations that imply that time dilation is *not* a physically observable phenomenon.

The Lorentz transformations, expressed in full, are

$$x' = \gamma(x - vt), y' = y, z' = z, \text{ and } t' = \gamma(t - vx/c^2),$$

where $\gamma = 1/\sqrt{1 - v^2/c^2}$.

The well-known mathematical deduction of time dilation from the Lorentz transformation for time is expressed as

$$\delta t = \gamma \delta t_0. \tag{1}$$

This is interpreted to represent the relationship of the time interval δt that transpires on relatively stationary synchronous clocks to the corresponding "proper" time interval δt_0 that transpires on another stationary clock in a system that is in relative uniform rectilinear motion. The physical interpretation of the time dilation expression (1) as the "slowing down" of time on a moving clock has been regarded as experimentally observable, were it only possible to move one clock relative to others that are stationary with a sufficiently high uniform translatory speed, so that a significantly detectable observation would be feasible.

It is therefore of utmost importance to make explicit certain physical characteristics of clocks whereby the asserted physical manifestation of time dilation might or might not be observable.

A clock is a device or meter for the measurement or the "telling" of time. It is a device that involves a condition of (preferably uniform) motion producing the successive repetition of the same relative spatial situation, and a means of counting the successive situations of rotational. vibrational, or oscillatory motion that are referred to as periods or cycles. The "telling" of time is accomplished by noting–to available technological accuracy–the integer number of periods and the fraction of a period as a phase angle through which a clock indicator has moved. The phase angle θ_0 (or its equivalent representation) through which the indicator of a stationary clock has been uniformly moved by the internal mechanism of the clock is directly proportional, by conventional definition, to the linear uniform passage of time. The factor of proportionality is the periodic behavior of a standard clock mechanism expressed as the *effective* constant angular speed ω_0 of the periodic motion of the clock. A time interval δt_0 is "told" by a reading of the phase angle θ_0 (or its equivalent representation), since by intended convenient definition and contrivance

$$\theta_0 = \omega_0 \delta t_0 . \tag{2}$$

The subscript zero explicitly connotes the parameters of a *relatively stationary* but otherwise uniformly running clock. The physical angular displacement θ_0 is usually directly calibrated in units of time and interpreted as a time interval as a matter of practical convenience. This convenience has been particularly conducive in masking the fact that time is *defined* by (2) in terms of a physical angular displacement characterized by θ_0 and a kinematic axial rotation characterized by ω_0. The physical concept of time arises from the fundamental primitive sensory recognition of relative physical position and the kinematic change of relative position called motion.

Consider a uniformly rotating right circular cylinder with circumferentially and uniformly spaced linear graduations parallel to its longitudinal axis of rotation. Just adjacent to the rotating cylindrical surface let there be a fixed stationary fiducial knife edge or taut fine wire erected parallel to the cylinder axis of rotation. The fiducial reference index together with the graduated surface of the rotating cylinder, shown in Fig. 1, can be regarded as an extended linear clock in the same sense that our axially rotating Earth can be thought of as an extended clock.

The parameters of such a clocklike rotating cylinder are shown by

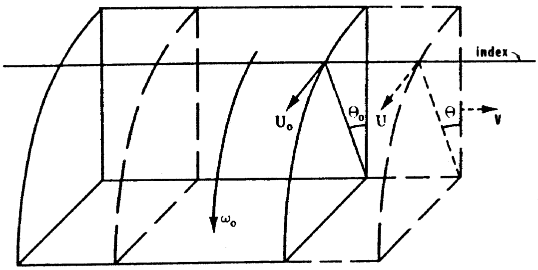

Fig. 1. Translating cylinder.

(2) for the case in which the cylinder is, apart from its constant rotation, at relative rest. Relative to a system of reference in which the clocklike rotating cylinder also translates uniformly in a direction parallel to its longitudinal axis of rotation, the parameters that characterize the relatively moving clock are given as

$$\theta = \omega \delta t. \tag{3}$$

A time interval δt with respect to the system through which the clock is translating uniformly is related to the "proper" time interval δt_0 in (2), for the system in which the clock is stationary, by time dilation as given by (1).

The phase angle of rotation θ_0 in any transverse plane normal to both the axis of rotation and the parallel direction of relative uniform translation, as in Fig. 1, is an invariant under the Lorentz transformations due to the identity transformations of the transverse coordinate axes. Thus, since $\theta = \theta_0$, it follows from (1)-(3) that

$$\omega = \omega_0/\gamma. \tag{4}$$

Reciprocal in nature to time dilation there is an angular frequency "compression," as a consequence of the Lorentz transformations, that characterizes the slower periodic uniform rotation of the uniformly translating clock.

Another clock identical to the translating clock, but at rest in the system through which the translating clock moves, will rotate through the same angle $\theta = \theta_0$, given by (2), that characterizes the rotation of the translating clock relative to the uniformly translating reference system in which it is at rest. A clock phase angle of rotation θ_0 (or its equivalent representation) is physically observable as a relative spatial displacement or distance, usually a circular arc, that is calibrated or interpreted as the passage of a physical time interval. It is a consequence of the Lorentz transformations that the physically observable quantity for "telling" or metering of time is the Lorentz-invariant clock phase angle of rotation $\theta_0 = \theta$ (or its equivalent representation). Time dilation (1) is compensated for by the reciprocal angular frequency "compression" (4), with the physical consequences that neither "effect" is physically observable. Relatively moving clocks in uniform translation would be observed to exhibit the passage of the same "universal" Lorentz time interval characterized by the phase angle $\theta_0 = \theta$ (or its equivalent representation). An immediate obvious benefit from the physical unobservability of time dilation, as a consequence of Lorentz-invariant "universal" time, is the "resolution" of the so-called clock paradox.

The Lorentz invariance of the angle of rotation $\theta_0 = \theta$ is also consistent with the Einstein "addition" theorem for *transverse* speeds, which is a consequence of the Lorentz transformations. The tangential speed U, indicated in Fig. 1, of the cylindrical periphery relative to the stationary system is expressed in terms of the tangential speed U_0 relative to the moving "proper" system as

$$U = U_0/\gamma(1 + U_v v/c^2) = U_0/\gamma, \tag{5}$$

since U_0 has no component U_v along the longitudinal direction of translation, so that $U_v = 0$. The radius of the cylinder and its orthogonality to the tangential peripheral vector velocity, in the transverse plane normal to the direction of translation, are invariant under the Lorentz transformations. Relative to the stationary system through which the cylinder moves, the tangential scalar speed of the cylindrical periphery is simply $U = r\omega$, corresponding to $U_0 = r_0\omega_0$ in the moving "proper" system. It follows since $r_0 = r$ that $\omega = \omega_0(U/U_0)$, which, with (5), implies (4).

Time dilation is implicitly regarded to be independent of the relative orientation of the effective angular vector velocity $\boldsymbol{\omega}$ of a clock with respect to the vector velocity $\mathbf{v}$ of relative uniform translation. Length contraction is orientation dependent, and takes place only along the direction of the vector velocity $\mathbf{v}$. The generalization of Lorentz-invariant "universal" time for the case when $\mathbf{v} \times \boldsymbol{\omega}_0 \neq 0$ follows from the invariant product of length contraction and time dilation,

$$\delta l\, \delta t = \delta l_0\, \delta t_0. \tag{6}$$

This means that length contraction $\delta l = \delta l_0/\gamma$ which, like angular frequency "compression," is reciprocal in nature to time dilation, must also be physically unobservable. Time dilation and length contraction are reciprocally compensatory, with the consequence that neither is physically observable. The circular face of a moving clock is invariantly circular—not elliptical—independent of its orientation with respect to the direction of relative motion v. The generalization for arbitrary clock orientation of Lorentz-invariant "universal" time ($\theta_0 = \theta$) therefore follows from the joint unobservability of length contraction and time dilation.

The unobservability of length contraction was first suggested in 1959 for different reasons by Terrell[1,2] and Penrose.[3] The physical unobservability of length contraction would "resolve" the latest length contraction paradox,[4-6] the first length contraction paradox having been proposed fifty years earlier in 1909 by Ehrenfest.[7] He argued that the circumference of a stationary but axially rotating circular cylinder or disk would be less than $2\pi r_0$ due to length contraction along its periphery, while its radius, being perpendicular to the tangential speed of the disk circumference, is unaltered; $r_0 = r$. Sama[8] attributed the Ehrenfest paradox "to an ambiguous notation" that is of no significant physical consequence. The Ehrenfest paradox is obviously "resolved" by the physical unobservability of length contraction. The experimental efforts[9-13] related to the detection of length contraction, though the subject of historically varied interpretation, have never given evidence of a physically observable length contraction effect, so that there has never been any *direct kinematic* experimental evidence that confirms length contraction as an observable physical phenomenon

Lorentz-invariant "universal" time follows as an explicit recognition of the physical nature of a spatially extended clock and its relationship with the identity transformations of the spatial coordinates that are transverse to the direction of motion. The transverse coordinate transformations, $y' = y$ and $z' = z$, define $\theta_0 = \theta$, whereby $\delta t_0 = \delta t$, which is in immediate contradiction with the concept of time dilation.

The constant "kinematic" temporal phase between any two fixed, separate, colinear points that comove along the direction of v is a consequence of the Lorentz transformation of time; it is expressed as

$$\pm\gamma v\delta x/c^2 = \pm v\delta x_0/c^2, \tag{7}$$

since by virtue of length contraction $\delta x = \delta x_0/\gamma$. The overlooked significant physical fact is that real clocks are not dimensionless. The physically observable angular displacement θ whereby time is "told" represents the *same* time at different spatial points over its own dimensions, particularly along its dimensional extent δx_0 in the direction of the relative translatory vector velocity v. The constant "kinematically" induced temporal phase difference for such spatially separated but comoving points must therefore *not* be observable, quite apart from the fact that no experimental attempt has ever been made to observe it. The unobservability of constant "kinematic" temporal phase is consistent with the unobservability of length contraction and time dilation.

It is universally understood that a network of independent clocks, stationary in any specified reference system, can be synchronized and could thereby be interconnected in a linear tandem array to a common rotating drive shaft. Such a synchronous network of clocks is physically equivalent to the clocklike rotating graduated cylinder depicted in Fig. 1.

From the concept of the synchronization of separate clocks or that of a spatially extended clock (since physical clocks are *not* dimensionless), it can be concluded that temporal phase, expressed in (7), is an untenable contradiction of the very idea of synchronization or the more fundamental property of the physical dimension of an actual clock. Instead, it is asserted (and uncritically accepted), *without proof* that simultaneous events in a "stationary" system are not simultaneous relative to a uniformly translating system. This assertion or "backdoor" hypothesis has become known as the "relativity of simultaneity" or the "relativity of synchroneity" in Einstein's theory. It can be seen at once to be in flat contradiction to the Lorentz-invariant "universality" of time, which is a consequence of the identity transformations of the transverse spatial coordinates.

The thought presents itself that the rotating clocklike cylinder in Fig. 1 might "appear" to be twisted about its longitudinal axis and so conform with (7). Such a torsion would *not* be consistent with the transverse transformations, $y' = y$ and $z' = z$, whereby $\theta_0 = 0$ and $\delta\theta_0 = \delta\theta$ *for all values of* x *or* x'.

It is possible to determine that spatially separated events are simultaneous, even though they occur at different *unsynchronized* clock indications. This can be done if the unsynchronized spatially separated clocks *run at the same rate* and at a *known constant* time difference, ahead of or behind each other. Thus, the dictionary definition of the words synchronous and simultaneous as synonyms is erroneous. This mischievous synonymity has been examined in detail elsewhere by the author,[14] from the point of view of the proponents of Einstein's theory. Some past paradoxes were resolved only to be replaced by further contradictions, which can be "resolved" only if v in the Lorentz transformations is identically zero.

The same inescapable conclusion has been shown in this chapter. The contradiction between Lorentz-invariant "universal" time, $t' = t$, and time dilation, $t = \gamma t'$, requires for its "resolution" that $\gamma = 1$, so that $v \equiv 0$, since $c \neq \infty$. The contradiction between *zero* temporal phase, due to Lorentz-invariant "universal" time, and an *inferred* kinematically induced temporal phase, $\pm \gamma v \delta x / c^2$, requires for its "resolution" that $v \equiv 0$, since $\delta x \neq 0$ and $c \neq \infty$.

The experimental evidence on the *time dilation of uniform translation* in Einstein's special theory of relativity will be examined in the sixth chapter. It will be seen that there is no clear evidence in support of that concept, attendant on the Lorentz transformation for time. The identity Lorentz transformations for the transverse spatial coordinates with their attendant Lorentz-invariant "universal" time, determined physically as an invariant angular displacement, contradicts the concepts of time dilation and kinematically induced temporal phase (relativity of simultaneity).

The independent deduction, presented above, for the physical unobservability of time dilation, while similar to conclusions put forth by Stephenson,[15] has been obtained here for distinctly different reasons, which are based on Lorentz invariants. The objections[16,17] directed at Stephenson's considerations are, therefore, not applicable here.

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