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# The Geographic Time-Differences of Clocks in the Lorentz Transformation

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## ABSTRACT

**It is** discovered that Lorentz transformations do not permit observers to synchronize all clocks with zero geographic time differences in two inertial systems. In order to guarantee the principle of the constancy of the velocity of light in a vacuum, observers must artificially adjust the rates and the geographic time-difference of the clocks in two inertial systems according to the geographic time- difference formula deduced by author from the Lorentz transformation.

**Key words** : geographic time-difference, artificial adjustment of clock

If we assume that the origin O of the Cartesian coordinates in system K coinciding with origin O' of Cartesian coordinates in system K' at the moment of time t=t'=o, and the Cartesian axes in K and K' are parallel to each other and that K' is moving relative. If we assume that origin O of the Cartesian coordinates in system K coinciding with the origin O' of Cartesian coordinates in system K with velocity v in the direction of the positive x-axis. Then the connection between these space-time coordinates is given by the Lorentz transformation

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}, \; y' = y, z' = z, \tag{1}$$

$$t' = \frac{t - vx/c^2}{\sqrt{1 - v^2/c^2}}. \tag{2}$$

Einstein had deduced from (1) and (2) by putting $x' = 0$ the following formula

$$\zeta' = \sqrt{1 - v^2/c^2}\, t, \tag{3}$$

where $t' = \zeta'$ is the time recorded by one clock situated at rest at the origin O′ and $t$ is the times recorded by a series of clocks situated at rest at different coincident points of the origin O′ on the x- axis. From ( 3 ) one can obtain

$$\Delta\zeta' < \Delta t \ , \tag{4}$$

which can not indicate that the moving clock situated at rest at origin O′goes slower than each resting clock which were at rest at different points on x-axis relative to K since $\Delta t$ depends on different clocks and then (4) has no physic significance.

Suppose $\zeta$ to be the time recorded by the clock situated at rest at origin O. If all clocks situated at rest at different points on the x-axis are synchronized with a zero geographic time-difference , we then have

$$t = \zeta \ . \tag{5}$$

From (4),(5) we obtain

$$\Delta\zeta' < \Delta t = \Delta\zeta, \tag{6}$$

which indicates that the moving clock situated at rest at the origin O′goes slower than each resting clock which is at rest at different points on x-axis relative to K.

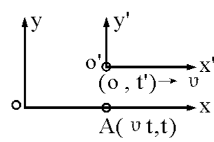


Fig 1. At the moment t(≠0) the origin O' reaches the point A on the x-axis where x= υ t

By putting $x = 0$ in (1), (2) one may obtain

$$\zeta = \sqrt{1 - v^2/c^2}\, t', \tag{7}$$

where $t = \zeta$ is to be the recorded time by the moving clock situated at rest at origin O, and $t'$ is the times recorded by a series of resting clocks situated at different coincident points of origin O on the x′- axis.

According to the relativistic properties of the moving state and resting state of a body, Einstein and his followers from (6), obtain

$$\Delta t = \Delta\zeta < \Delta t', \tag{8}$$

and then assert that the moving clock situated at rest at origin O goes slower than every resting clock, which is at rest relative to k′. We point out that this assertion is wrong since the time difference $\Delta t'$depends on two clocks situated at rest at different coincided points of the origin O on the x′-axis . If (5) holds we will prove that $t' = \zeta'$and $\Delta t' = \Delta\zeta'$ do not hold.

Consider two clocks C ′1 and C′2. Clock C′1 is situated at rest at origin O' and clock

C′$_2$ is situated at rest at point A' specified by the coordinate x'=x'$_1$ (>0) Again consider two clocks C$_1$ and C$_2$ , which are situated at rest at points A$_1$ and A$_2$ specified by coordinates x=x$_0$(>0), x=x$_1$(>x$_0$) respectively on the x-axis in system K. When clocks C$_1$ and C$_2$ record time x$_0$ /v, origin O' reaches the point A$_1$, while clock C′ $_1$ records time τ' and point A' reaches e point A$_2$, while the observer who is at rest at point A' on the x'-axis with the observer who is at rest at point A$_2$ on the x-axis record the same time t = x$_0$/v from clock C$_2$ and record the same time t'=t'$_1$ from clock C'$_2$ (see Fig.2) .We then have following corresponding relationship of space-time coordinates in systems K and K'

$$( x_0, t ) \longleftrightarrow ( 0, \tau' ), \tag{9}$$

$$( x_1, t ) \longleftrightarrow ( x'_1 , t'_1 ). \tag{10}$$

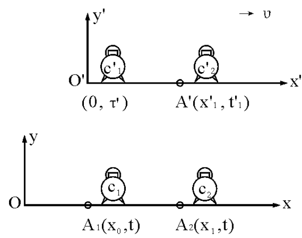


Fig 2. When t=x$_0$/v, origin O' reaches e point A$_1$ specified by coordinate x=x$_0$ on the x-axis

Putting (9) , (10 ) into the Lorentz transformation respectively, we obtain four algebraic equations which have six variables x$_0$, t, τ', x$_1$, x'$_1$ and t'$_1$. Eliminating three variables x$_0$, t, and, x$_1$, we obtain one equation which has another three variable

$$t'_1 = \zeta' - vx'_1/c^2 , \tag{11}$$

where τ' is the recorded time by the clock situated at rest at origin O' and t'$_1$ is the recorded time by the clock situated at rest at any fixed point specified by coordinate x'=x'$_1$ on the x'-axis in system K'.
Therefore formula (11) can be expressed in the general form

$$t' = \zeta' - vx'/c^2 , \tag{12}$$

where the term $-vx'/c^2$ is the geographic time-difference between the clock situated at rest at the point specified by coordinate x' (≠0) on the x'-axis and the clock situated at rest at origin O' of system K'
Therefore (12) shows that $t' = \zeta'$ and $\Delta t' = \Delta\zeta'$ can not hold, if $x' \neq 0$ and $\Delta x' \neq 0$.

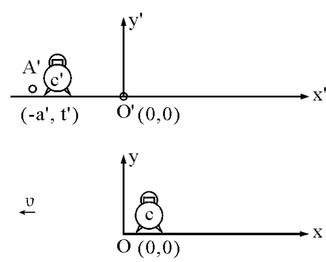


Fig 3. At t'=t=0, the clock C which is situated at rest at origin O coinciding with origin O' while the clock C' which is

situated at rest at point A' specified by coordinate $x'=x'_1=-a'$ on the x'-axis records time $t'=va'/c^2$.

In order to give out the correct physical interpretation for (7) , let us consider a clock C which is situated at rest at origin O and moving with velocity -v along the negative direction of the x'-axis relative to K'(see Fig. 3. We will compare clock C with another clock C' which is situated at rest at point A' specified by coordinate $x'=x'_1=-a'$ on the x'-axis. When $t=t'=0$ the origin O coinciding with the origin O'. While ζ' = 0, by putting ζ' = 0 and x'=-a' into Eq.(12), we obtain $t' = t'_0 = va'/c^2$ which is the recorded initial time by clock C' while clock C records the time $t=0$. When origin O reaches point A ', we assume clock C records time $t=\zeta$ (>0) and clock C' records the time $t'=t'_1$ while origin O' reaches the point specified by coordinate x = v ζ. Origin O with its coinciding point A' presents the corresponding relation of space-time coordinates as follows

$$(0,\zeta) \longleftrightarrow (-a', t'_1). \tag{13}$$

Origin O' with its coinciding point on x-axis x = v ζ presents the corresponding relation of space-time coordinates as follows

$$(v\zeta, \zeta) \longleftrightarrow (0, \zeta') \quad , \tag{14}$$

Putting (13) , (14) into (1), (2) respectively, we obtain

$$a' = v\zeta / \sqrt{1-v^2/c^2}, \tag{15}$$

$$t'_1 = \zeta / \sqrt{1-v^2/c^2}, \tag{16}$$

$$\zeta' = \sqrt{1-v^2/c^2}\, \zeta \quad 。 \tag{17}$$

When clock C meets clock C', for clock C we have $\Delta t = \Delta\zeta = \zeta - 0 = \zeta$ and for clock C' we have $\Delta t' = t'_1 - t'_0 = t'_1 - va'/c^2$. By means of (15),(16) , we obtain

$$\Delta t' = \sqrt{1-v^2/c^2}\, \zeta = \sqrt{1-v^2/c^2}\, \Delta\zeta \quad , \tag{18}$$

which leads to

$$\Delta\zeta > \Delta t' \quad , \tag{19}$$

which shows that the moving clock C goes faster than every resting clock situated at rest at different points on x'-axis since a′ is to be arbitrary chosen. When all clocks situated at rest at different points on K are synchronized with a zero geographic time difference, that means (5) holds, the observers must artificially adjust the rates and the geographic time-difference of the clocks situated at rest at different points in two inertial systems according to the geographic time- difference formulas (12) and (17) deduced by author from the Lorentz transformation. Therefore we have the non-symmetric geographic time difference formulas (NSGTD formulas)

$$t = \zeta, \tag{20.1}$$

$$t' = \zeta' - vx'/c^2 \quad , \tag{20.2}$$

$$\zeta' = \sqrt{1 - v^2/c^2}\ \zeta \quad . \tag{20.3}$$

Since (19) is not to be reciprocally exchanged for different observers at rest at different points in K and K′ , the concept of ideal clocks is therefore compatible with the Lorentz transformation

Replace velocity $c$ of light in vacuo by the velocity of voice in a static atmosphere in (12),(17) we can obtain the principle of the constancy of the velocity of voice in an atmosphere and therefore Einstein's principle of relativity still holds in a blind persons space-time

Replace NSGT formulas, if the observers in K′ , K artificially set the clocks in K′ , K according to the following symmetric geographic time differences formulas (SGTD formulas)

$$t' = \zeta' - \lambda\ x' \quad , \tag{21.1}$$

$$t = \zeta + \lambda\ x \ , \tag{21.2}$$

$$\zeta' = \zeta \ , \tag{21.3}$$

where

$$\lambda = (1 - \sqrt{1 - v^2/c^2}\,)/v \ ,$$

the Lorentz transformation (1), (2) are transformed into the Galilean transformation

$$x' = x - V\ \zeta \ , \quad y' = y \ , z' = z \quad , \tag{22.1}$$

$$\zeta' = \zeta \ , \tag{22.2}$$

where

$$V = \frac{v}{\sqrt{1 - v^2/c^2}} \ . \tag{22.3}$$

By means of the SGTD formulas, the Lorentz transformations （1),（2） have been derived from the Galilean transformation, which relates the ideal clocks with a zero geographic time difference ( note.1 ). Therefore even if some one in some day negates the principle of the constancy of the velocity of light in a vacuum by experimental measurements, the Lorentz invariance and the principle of relativity still hold. The concepts of ideal clock and geographic time difference will become a saving factor for Einstein's relativity.

# Reference


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