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The Inviolable Symmetry of the Reciprocity Paradox in an Empty Space

Abstract

Two spaceships, A and B, are in motion relative to each other. Their motion relative to the empty space they are in is undefined and undefinable. We can consider ship A to be stationary relative to space and ship B to be moving or vice versa. The two situations are entirely equivalent. Each ship's motion relative to the other is symmetric. Relative to a clock in either ship, an identical clock in the other ship appears to tick more slowly. This reciprocity paradox, also termed the twin paradox, is unresolvable in a geometric analysis. The history of which ship accelerated to produce their velocity difference is irrelevant and offers no solution to the paradox. If the two ships are brought together, motionless relative to each other, their clocks will tick at the same rate and neither clock will have lost time relative to the other. The symmetry of their motion relative to each other is inviolable. Both clocks cannot tick more slowly than their counterparts. Therefore, neither clock can tick more slowly than the other. The reciprocity paradox is an illusion. The motion between two reference frames in a space without properties that yields the inviolable symmetry of the reciprocity paradox tells us that geometric relationships cannot govern the physics of time dilation. The motion that violates this symmetry must be motion relative to a space with properties. This space must contain something that can be used to reckon motion. This something is a field that supports the propagation of photons and other force particles. This field is identified as the ***temporal-inertial*** (TI) field.

Objectives of This Study

Table 1 lists the arguments to be advanced in this paper. The traditional geometric analysis of two reference frames moving relative to one another in an empty, propertyless space leads to the reciprocity paradox that arguably is not a paradox at all, but an illusion. The principle assertions of this paper are that time dilation does not occur in an empty, propertyless space, but does in a space permeated with particles of the TI field that supports the propagation of photons and other force particles. Given the validity of these assertions, time dilation occurs between the two frames and the reciprocity paradox is violated.

Table 1. Arguments to be Discussed in This Paper

Item	Lemmas
1	The reciprocity (twin) paradox is an illusion that results from the assumption of a propertyless space in the analysis of the time dilation between two frames of reference moving relative to each other.
2	There is no effect on a process that is moving through an empty space. Conclusion: Clocks moving through an empty space all tick at the same rate.
3	There is no time dilation between one clock and another moving at a different velocity through an empty space and therefore the reciprocity paradox is an illusion.
4	The geometric symmetry and the ***apparent*** time dilation of the reciprocity paradox is acknowledged, but the actual time dilation assumed to occur in the traditional analysis is an illusion.
5	The only way to violate the symmetry of the reciprocity paradox is to postulate the existence of a field (identified as the ***temporal-inertial*** (TI) field) that supports the propagation of photons and other force particles.
6	The existence of the TI field enables the violation of the symmetry of the reciprocity paradox by the difference in velocity of two clocks relative to the TI field. If two clocks move relative to each other, at least one of them moves relative to the TI field.
7	The reciprocity paradox is symmetrical and inviolable in an empty space.

Strangers on a Train

If you have ever ridden on a train you may have experienced a form of the reciprocity illusion. You're sitting in coach in a stationary train in the station. The train adjacent to yours starts to move and you're not certain whether your train or the other train is moving. The motion of the trains relative to each other is symmetric (except for rotation of the wheels). A passenger in the other train can look at your train and have the same experience. Imagine that as the other train moves, a passenger on the train tosses a ball into the air. Inside the moving train the ball appears to move straight up and down. The view from your perspective shows the ball moving in a parabolic arc as illustrated in Figure 1. The horizontal component of the ball's velocity is that of the moving train.

Now imagine that your train is moving and the adjacent rain is stationary. Again, you may confuse the motion of your own train as motion of the other. (If you don't look at the wheels or the ground.) The passenger in the other train again tosses a ball straight up into the air and from your perspective the ball appears to move in a parabolic arc as illustrated in Figure 2. The vertical component of the ball's velocity is real, the apparent horizontal velocity is the negative velocity of your own train. It is an illusion.

The two examples appear symmetric and geometrically they are. The tossed balls appear to follow the same trajectories in both examples, but one trajectory is real and the other is an illusion. Physically, one or the other train does move relative to space and that fact violates the symmetry of the examples. We'll see in the next thought experiment that the relative motion of two vehicles is truly symmetric, because neither moves relative to an empty, propertyless space. The perceptions viewed from each vehicle to the other are both illusory and cannot be resolved by a geometric analysis.

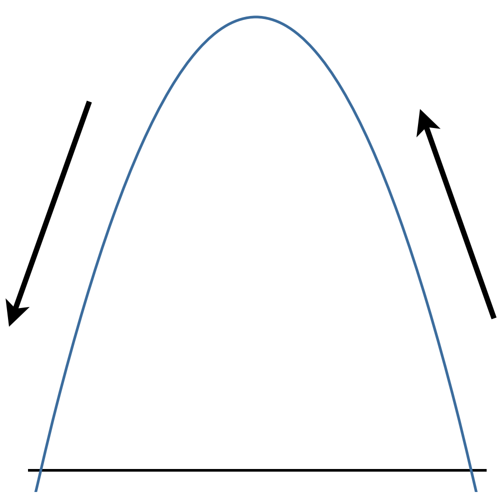

Figure 1. Path of a Ball Tossed Vertically in the Moving Train From the Perspective of the Stationary Train

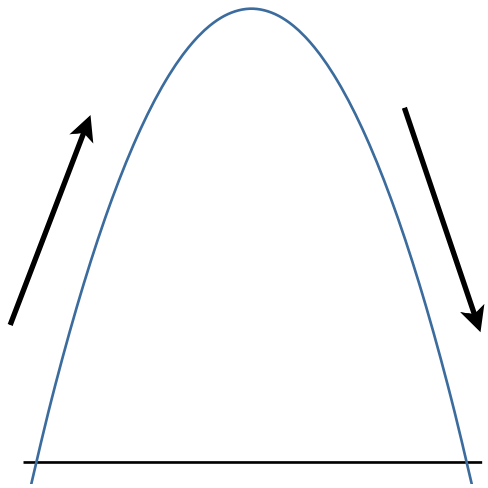

Figure 2. Apparent Path of a Ball Tossed Vertically in the Stationary Train From the Perspective of the Moving Train

Recapitulation, The Period of the Baseball Clock

What's the period of the baseball clock? It's the time it takes the ball thrown into the air to fall back to the hand of the passenger who tossed it into the air. Not too scientific a test, but it will do to illustrate a point. Does the period of the clock depend on the velocity of the train in which the ball was tossed? No, the period depends on the height of the toss and gravity. The moving train provides the horizontal velocity of the ball in its flight, but does not affect the vertical motion of the ball. The period would be the same whether the ball was tossed in a stationary train or a train moving at high speed.

If you were tossing the ball in your stationary train, the stranger in the adjacent moving train (an experienced analyst) would see the apparent arc of your baseball and judge the period of the ball to depend only on the height of the toss and gravity.

In these examples, only the vertical component of the ball's motion determined the period of the ball's flight. The horizontal component of the ball's motion, whether real or illusory, had no effect on the period of the ball's flight. In the following sections, we will look into the analogy between the flight of the ball and the transit of a photon from point to point in an idealized photon clock. The photon clock serves as an exemplar of any process that consumes time.

The Reciprocity Paradox

"When two observers are in relative uniform motion and uninfluenced by any gravitational mass, the point of view of each will be that the other's (moving) clock is ticking at a slower rate than the local clock. The faster the relative velocity, the greater the magnitude of time dilation. [1] Relative to a clock in either ship, an identical clock in the other ship appears to tick more slowly. This phenomenon is termed the reciprocity paradox.

The reciprocity paradox produced by the motion of one arbitrary frame relative to another in an empty space is an illusion. An entity can move through space from one arbitrary reference point to another but it does not move relative to space because empty space provides no reference for motion. Rather, consider the motion of an entity through space from the perspective of the entity itself. Does space flow past the entity with the velocity of the entity? The obvious answer is no. There is no such flow because there is nothing in an empty space to flow. Accordingly, motion of an entity through empty space has no influence of any kind on the entity. If the entity is a clock or, more broadly, any process, the process is unaffected by its motion through an empty space. There is no effect on the period of a clock, a chemical reaction or a biological process by its motion through an empty space.

The Lorentz transformation [2] is a mathematical construct relating the difference in the passage of time between two frames of reference moving relative to each other in either an empty, propertyless space or a space charged with a medium supporting the propagation of photons and other force particles. Unfortunately, in relating the differential passage of time between two frames moving in an empty space, the transform is misapplied to the physics of time dilation. Explanation to follow.

The Lorentz transformation is not in itself an exemplar of a physical process. The photon clock is such an exemplar and provides insight into nature's fundamental clocks, the exchange of force particles that determines the tempo of all of nature's processes.[3] The transit time of force particles in the interaction between other fundamental particles (e.g. proton and electron) is a function of the velocity of the fundamental particles through a space permeated with a medium that supports the propagation of photons and other force particles. The function relating the ratio of the transit time (process duration) of this particle exchange between a moving and stationary process is the Lorentz factor $\gamma = 1 / (1 - v^2/c^2)^{1/2}$, where v is the velocity of the process relative to the TI field and c is the velocity of light relative to the TI field. [4]

The Geometric Interpretation of Time Dilation and the Reciprocity Paradox

Time dilation has been defined as the decrease in the rate of flow of time in a frame of reference moving with respect to an outside observer in a second frame of reference. Fundamental to the geometric interpretation of time dilation is the assumption that space is without properties other than dimensionality. This featureless space is devoid of any medium to support the propagation of force particles, such as the photon. This space provides no reference frame by which to reckon the motion of photons and other force particles. An arbitrary system of coordinates, a frame, must be established to enable the measurement of motion. There can be no other means by which to reckon motion in a space without properties.

The geometric view expresses time dilation as a function of the difference in velocity between two frames moving relative to one another. I contend that time dilation is a function of the velocity of an entity relative to the TI field, not a function of the velocity of the entity relative to an arbitrary frame of reference in a space without properties.

The geometric view does not address the physics of time dilation. The physics of time dilation are not governed by geometry, but are more fundamental. The physics of time dilation occur at the subatomic level and affect all processes that move relative to the TI field. [4]

The Experimental Setup

- Two spaceships, A and B, are in motion relative to each other.
- Each ship's motion relative to the other is symmetric.
- Each ship contains an identical clock comprising a laser, two mirrors and a detector.
- The laser, located at the lower mirror, emits short pulses of photons toward the upper mirror. The photons reflect off the mirror and are detected at the second mirror. The mirrors are a vertical distance d apart. The period of the clock is defined as the time it takes for a photon to travel from the lower mirror to the upper mirror and back again.
- The photons move at the velocity of light c.

The Temporal-Inertial (TI) Field

Much of the discussion in this paper is derived from references [5] and [6].

- A field of particles termed the ***temporal-inertial*** (TI) field permeates space.
- The TI field provides a frame of reference for the motion of photons and other force and messenger particles.
- The TI field supports the propagation of photons and other force particles (except gravitons).
- Motion can be reckoned relative to the particles of the TI field.

We'll look first at the behavior of a photon clock operating in a space devoid of the TI field, a space devoid of anything, a space without properties.

Brief Notes on Definitions

An empty space provides no reference for motion nor does it provide a reference for orientation. In the arguments to follow about motion in an empty space reference frames for motion and orientation reside in the axes of two spaceships. Horizontal or longitudinal means parallel with the longitudinal axis of each ship, vertical means perpendicular to this axis. The velocity vector of each ship is parallel with the longitudinal axis of the ship. The mirrors of the photon clock are disposed one above the other or on a line that is perpendicular to the longitudinal axis of the ship.

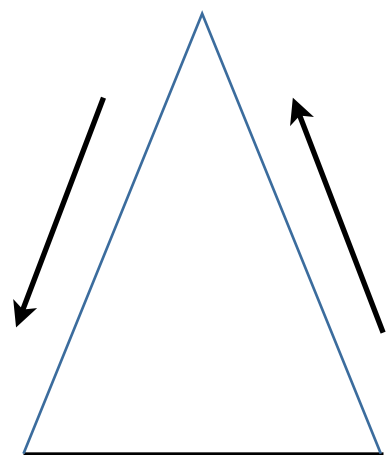

Figure 3. Apparent Path of a Photon Beam Directed Vertically in a Relativistic Spaceship From the Perspective of a Stationary Observer (The vertical distance from the base to the apex of the triangle is d.)

The apparent path of photons in an idealized photon clock is depicted in Figure 3. From the perspective of an outside observer the apparent path of photons of the clock describe a sawtooth or triangular pattern rising from the lower mirror of the clock, reflecting from the top mirror (at the apex of the triangular path) and returning to the lower mirror.

Motion Relative to Empty Space Has No Effect on the Path of the Photons

Consider the path the photons travel in the propertyless space. Recognize that the thesis of this paper is that a medium (the TI field) supporting the propagation of photons exists in the real world. In a space without properties, this medium does not exist. ***Consequently, the behavior we ascribe to the motion of photons in an empty space is arbitrary and dependent on the assumptions we make about their motion.*** The assertion here is that the photons assume ballistic paths unaffected by their motion through an empty space.

Empty Space and the Symmetry of Motion of the Two Ships Leads to the Reciprocity Paradox

Our next thought experiment is conducted in a space devoid of properties other than dimensionality. There is no TI field to support the propagation of the photons, but we'll assume that they move at a velocity of c. The photons move in ballistic paths unaffected by the space they traverse. The motion of the ships relative to an empty space is undefined. The difference in velocity between the two ships is v. We can consider ship A to be stationary relative to space and ship B to be moving or vice versa.

The two situations are equivalent. The motion of each ship relative to the other is symmetric. Relative to a clock in either ship, an identical clock in the other ship appears to tick more slowly. This phenomenon is termed the reciprocity paradox. The paradox is unresolvable in a geometric analysis. The history of which ship accelerated to produce the difference in their velocity is irrelevant. If the two ships are brought together, motionless relative to each other, their clocks will tick at the same rate and neither clock will have lost time relative to the other. The symmetry of their motion relative to each other and the identity of their tick rates is inviolable. The apparent difference in the tick rates of their clocks, that is termed the reciprocity paradox, is an illusion.

Refer to Figure 3 and examine the operation of the clocks aboard the spaceships. Each simplified clock comprises two mirrors, a laser and a photon detector. The laser of clock B is aimed straight up toward the upper mirror. The laser emits short pulses of photons toward the upper mirror in the figure, the photons reflect off the mirror and are detected at the second mirror. The mirrors are a vertical distance d apart. The period of the clock is defined as the time it takes a photon to travel from the lower mirror to the upper mirror and back again. The period of a stationary clock is then 2d/c where c is the velocity of light in space.

From the perspective of each ship the photon path of the other ship's clock describes a sawtooth pattern as the photons reflect between the two mirrors of the clock. The traditional interpretation holds that the velocity of the photons is c along the diagonals of the sawtooth pattern. I contend that the vertical component of the photon velocity is c and the horizontal component of velocity is the velocity of the ship and clock relative to the observer in the other ship. This contention would appear to violate Special Relativity that restricts the velocity of light to the value c. My argument follows.

Either ship can be considered the reference for motion of the other. If we consider ship A to be stationary and ship B to be moving at v relative to ship A, then the sawtooth pattern described by the photons of clock A in ship A is an illusion. Ship A is stationary and the path of its photons is straight up and down. The period of its photon clock is 2d/c. There is no time dilation of clock A relative to clock B. As seen from ship A, of course, the clock of ship B ticks more slowly than clock A.

It's equally valid to consider ship B to be stationary and ship A to be moving away from ship B at velocity -v. The apparent sawtooth pattern of ship B's photon path seen from ship A is then an illusion caused by the motion of ship A itself. The path of the photons of clock B is straight up and down and the period of clock B is 2d/c. There is no time dilation of clock B relative to clock A. As seen from ship B, of course, the clock of ship A ticks more slowly than clock B. Table 2 compares the apparent time dilation of the reciprocity paradox with the real null time dilation that occurs between two ships moving in an empty space. In the table, ship B and its clock move at velocity v relative to ship A and its clock. Relative to each ship the clock in the other ship ticks more slowly (has a greater period). The ratio of the periods of the two clocks is given in columns 3 and 4 of the table. The apparent time dilation is the same for each observer. The ratios of the real time dilation between the two clocks is 1, meaning that there is no time dilation between the two clocks.

Table 2. The Apparent Time Dilation (Reciprocity Paradox) and the Real Time Dilation between Two Ships Moving in Empty Space

Ship A Velocity	Ship B Velocity	Apparent Time Dilation t_B / t_A	Apparent Time Dilation t_A / t_B	Real Time Dilation t_B / t_A or t_A / t_B
0	v	$1 / (1-v^2/c^2)^{1/2}$	$1 / (1-v^2/c^2)^{1/2}$	1

The situation is similar, if not analogous, to that of the ball toss on the moving train. The vertical speed of the ball depends only on its launch speed and gravity and is unaffected by the motion of the train. The period of the toss from toss to catch is the same whether the train is moving or stationary.

The only way to violate the symmetry of the clock behavior is to postulate the existence of a medium (the TI field) that supports the propagation of photons and other force particles. Then if the two ships move relative to each other, at least one of them moves relative to the TI field. Motion relative to the TI field is the root cause of time dilation. [6] Table 3 summarizes the behavior of the two clocks moving in an empty space.

Table 3. Summary of the Behavior of Two Clocks Moving in Empty Space

Item	Behavior
1	Parentheses are used around ‘stationary’ and ‘moving’ because displacement and motion relative to an empty, propertyless space is undefinable and meaningless.
2	In an empty space, either ship can be considered to be the stationary reference while the other ship is moving.
3	Two spaceships in an empty space move relative to each other with velocity v.
4	Each ship has an identical photon clock*, as described below and depicted in Figure 3.
5	The geometry of the two ships is symmetrical. From the perspective of each ship, the clock in the other ship appears to tick more slowly. This is the reciprocity paradox.

Item	Behavior
6	In an empty space, motion relative to space is undefinable and meaningless. At the clock in the ‘moving’ ship, space moves past the clock at minus the velocity of the ship relative to the ‘stationary’ reference. This so-called motion of empty space relative to the clock can have no effect on the path of the photons. ***The photons move through space with the ship, but not relative to that space.*** Accordingly, the vertical component of the photon path is unchanged at the velocity of light c. The period of the clock remains 2d/c and there is no time dilation of the ‘moving’ clock relative to the ‘stationary’ reference clock. No time dilation means that both ‘moving’ and ‘stationary’ clocks tick at the same rate. The reciprocity paradox is illusory. The symmetry of motion and the null effect on clock rate of the two ships is inviolable in an empty space.
7	From the ‘moving’ ship, the photon path of the clock in the ‘stationary’ ship describes a sawtooth pattern as the photons reflect between the two mirrors. The longitudinal component of velocity of the photon path of the clock in the ‘stationary’ ship is the apparent velocity of the ‘stationary’ ship and is an illusion. The vertical component of the photon path is c, the velocity of light. The period of the clock is the transit time of the photons moving from one mirror to the other and back again, a distance of 2d. The period of the clock is therefore 2d/c.
*	Refer to Figure 3 and examine the operation of the clocks aboard the spaceships. Each simplified clock comprises two mirrors, a laser and a photon detector. The laser of clock B is aimed straight up toward the upper mirror. The laser emits short pulses of photons toward the upper mirror in the figure, the photons reflect off the mirror and are detected at the second mirror. The mirrors are a vertical distance d apart.

Motion of the Two Ships in Space Permeated by Particles of the TI Field Violates the Reciprocity Paradox

My point in the paper is that the reciprocity paradox exists, but is an illusion, because the assumption of empty space precludes motion through space having any effect on the path of photons or other force particles. Motion, say of a spaceship, through an empty space is undefinable. The spaceship may move through an empty space, but it doesn’t move relative to that space. You may reckon motion relative to an arbitrary frame (the location of a second spaceship), but there is no motion relative to an empty space. Or maybe I should say there is no effect on a process that is moving through an empty space. Conclusion: clocks moving through an empty space all tick at the same rate. There is no time dilation between one clock and another moving at a different velocity through an empty space and therefore the reciprocity paradox is an illusion. I acknowledge the symmetry, but not the time dilation assumed to result. The symmetry of reciprocity cannot be resolved by any geometrical analysis. The only way to violate the symmetry is to postulate the existence of a field that supports the propagation of photons. The existence of the field that supports the propagation of photons changes the whole problem. First, there is now real time dilation caused by the velocity of a clock, or any process, relative to the TI field, [5] [6] not velocity relative to some arbitrary reference (as another clock). Second, the symmetry is violated by the difference in velocity of the two clocks relative to the TI field. If two clocks move relative to each other, at least one of them is moving relative to the TI field.

Motion relative to the TI field is the root cause of time dilation. Time dilation of any process is a function of the velocity of that process relative to the TI field. The time dilation of a clock (a valid representative of a process) in a moving spaceship increases with the velocity of the ship relative to the TI field. If two ships move relative to each other one will have a greater velocity relative to the TI field than the other and the periods of their two clocks will differ. The geometric symmetry of the motion of the two ships does not affect the physics of time dilation.

Even though there is geometric symmetry in the motion of the two ships, the symmetry of the associated physics of time dilation is violated by the difference in velocity of the ships relative to the TI field. Despite the geometric symmetry, the two clocks tick at different rates. The period of a moving clock, or any process, is increased by the factor γ relative to the period it would have if it were stationary relative to the TI field. [6] The factor γ is the Lorentz factor and it is given by

$$\gamma = 1 / (1 - v^2 / c^2)^{1/2} \qquad (1)$$

where

v is the velocity of the clock or process relative to the TI field.

c is the velocity of light relative to the TI field.

Time Dilation of Two Ships Moving in the TI Field

Let both ships move relative to the TI field. Ship A moves at velocity v_1 relative to the field and ship B moves in the same direction at velocity v_2. Both clocks will now experience time dilation in accordance with Eqs (2) and (3). [5] [6]

$$t_1 / t_0 = 1 / (1 - v_1^2 / c^2)^{1/2} \qquad (2)$$

$$t_2 / t_0 = 1 / (1 - v_2^2 / c^2)^{1/2} \qquad (3)$$

where

v_1 is the velocity of clock A relative to the TI field.

v_2 is the velocity of clock B relative to the TI field.

t_1 / t_0 is the ratio of period t_1 measured by clock A with respect to the period t_0 that would be measured by an identical clock that is stationary relative to the TI field.

t_2 / t_0 is the ratio of period t_2 measured by clock B with respect to the period t_0 measured by the stationary clock.

The ratio of the periods measured by the two clocks is obtained by dividing Eq (3) by Eq (2):

$$t_2 / t_1 = (1 - v_1^2 / c^2)^{1/2} / (1 - v_2^2 / c^2)^{1/2} \qquad (4)$$

Table 4 summarizes the apparent and intrinsic time dilation between clocks A and B aboard ships A and B for three values of velocity of the ships relative to the TI field. The ***apparent*** ratio of the periods between the two clocks is a function of the difference in velocity between the two ships. This is the reciprocity paradox and it is illusory. The ***intrinsic*** ratio of the periods between the two clocks is a function of each ship's velocity relative to the TI field, not a function of either ship's velocity relative to the other. [5] [6]

Table 4. Real and Apparent Time Dilation Between Two Ships Moving in The TI Field of Space

Ship A Velocity Relative to TI Field	Ship B Velocity Relative to TI Field	Apparent t_B / t_A or t_A / t_B	Intrinsic t_B / t_A
0	v	$1 / (1-v^2/c^2)^{1/2}$	$1 / (1-v^2/c^2)^{1/2}$
-v/2	v/2	$1 / (1-v^2/c^2)^{1/2}$	$(1-(v/2)^2/c^2)^{1/2} / (1-(v/2)^2/c^2)^{1/2} = 1$
u	v (v > u)	$1 / (1-(v-u)^2/c^2)^{1/2}$	$(1-u^2/c^2)^{1/2} / (1-v^2/c^2)^{1/2}$

Table 5 summarizes the behavior of two clocks moving in the TI field of space.

Table 5. Summary of the Behavior of Two Clocks Moving in Space Permeated With Particles of the TI Field

Item	Behavior
1	The TI field provides a reference for motion.
2	Two spaceships move within the TI field. The velocity of each ship relative to the field must be considered in determining the intrinsic value of each ship's time dilation and the time dilation of either ship relative to the other. [5] [6]
3	Each ship has an identical photon clock*, as described below and depicted in Figure 3.
4	The geometry of the two ships and their clocks is symmetrical. From the perspective of each ship, the clock in the other ship appears to tick more slowly. The ***apparent*** difference in tick rate between the two clocks is a function of the difference in velocity between the two ships. This is the reciprocity paradox and it is illusory.
5	The ***intrinsic*** time dilation between the clocks in the two ships is a function of each ship's velocity relative to the TI field, not a function of either ship's velocity relative to the other. [5] [6]
6	From moving ship B, the photon path of the clock in stationary ship A describes a sawtooth pattern as the photons reflect between the two mirrors. The apparent longitudinal component of velocity of the photon path of the clock in the stationary ship is the apparent velocity of the stationary ship and is an illusion. The vertical component of the photon path is c, the velocity of light. The period of the clock is the transit time of the photons moving from one mirror to the other and back again, a distance of 2d. The period of the clock is therefore 2d/c.

Item	Behavior
7	The traditional interpretation of the behavior of clock A in the stationary ship is that the photon velocity is c along the diagonals of the sawtooth pattern of the photons. This behavior would increase the period of the clock by the factor γ where $\gamma = 1 / (1 - K^2)^{1/2}$ and K = v / c. As shown in the next panel this value equals the value for clock B in the moving ship. This behavior would imply reciprocity with that of the moving ship. However, this behavior is an illusion; the vertical component of velocity is c. The horizontal component of velocity of the photons is illusory. The period of clock A is 2d/c.
8	The longitudinal component of the velocity of the photons in clock B is the velocity v of ship B. The vertical component of the velocity of the photons in clock B is c / γ where $\gamma = 1 / (1 - K^2)^{1/2}$ and K = v / c. The period of clock B is 2d * γ / c. Clock B ticks more slowly than clock A and there is no intrinsic reciprocity.
9	Even though there is geometric symmetry in the motion of the two ships, the symmetry is violated by the difference in velocity of the ships relative to the TI field. Despite the geometric symmetry, the two clocks tick at different rates. The period of clock B is increased by the factor γ relative to the period it would have if it were stationary relative to the TI field. The period of clock B differs from that of clock A by the same factor γ because clock A is stationary relative to the TI field.
*	Refer to Figure 3 and examine the operation of the clocks aboard the spaceships. Each simplified clock comprises two mirrors, a laser and a photon detector. The laser of clock B is aimed straight up toward the upper mirror. The laser emits short pulses of photons toward the upper mirror in the figure, the photons reflect off the mirror and are detected at the second mirror. The mirrors are a vertical distance d apart. The mirrors are a vertical distance d apart. The period of the clock given here neglects the effect of length contraction of the clock. [5]

Conclusions 1. The Experimental Setup

1. Two spaceships, A and B, are in motion relative to each other.
2. Each ship's motion relative to the other is symmetric.
3. Each ship contains an identical clock comprising a laser, two mirrors and a detector.
4. The laser, located at the lower mirror, emits short pulses of photons toward the upper mirror. The photons reflect off the mirror and are detected at the second mirror. The mirrors are a vertical distance d apart. The period of the clock is defined as the time it takes a photon to travel from the lower mirror to the upper mirror and back again.
5. The photons move at the velocity of light c.

Conclusions 2. Time Dilation Does Not Occur in an Empty Space

1. Space is empty.
2. Motion through an empty space has no influence on the path of a photon.
3. The vertical velocity of photons of the photon clock is unaffected by the velocity of the clock through an empty space.
4. As viewed from the perspective of ship A, the path of photons of clock B in ship B describes a sawtooth pattern, reflecting back and forth between the two mirrors of the clock.
5. Conventional analysis assumes that the photon velocity c occurs along the diagonals of the clock. Accordingly, the period of the clock would be greater than when the clock is stationary. To repeat item 3: The vertical velocity of the photons of the photon clock is unaffected by the velocity of the clock through an empty space. The period of the clock is thus unaffected.
6. As viewed from the perspective on each spaceship, the clock in the other spaceship appears to be ticking slower. This is the reciprocity paradox and it is an illusion.
7. Either ship may be considered as the reference for motion of the other. If ship A is the 'stationary' reference, ship B moves away at velocity v. The horizontal velocity of photons in its clock move at v relative to reference ship A. This is real motion relative to ship A. Relative to ship B, ship A and its clock move away from ship B at velocity of -v. The apparent horizontal velocity of photons in clock A is -v and is an illusion.
8. Reverse the assignment of the stationary reference from ship A to ship B. If ship B is the 'stationary' reference, ship A moves away at velocity -v. The horizontal velocity of photons in its clock move at -v relative to reference ship B. This is real motion relative to ship B. Relative to ship A, ship B and its clock move away from ship A at velocity of v. The apparent horizontal velocity of photons in clock B is v and is an illusion.

9. The views of items 7 and 8 are symmetrical.
10. The phenomena described in items 3-9 occur regardless of which ship accelerated to produce the difference in their velocity.
11. Item 3 asserted that regardless of the motion of a photon clock through an empty space, the vertical velocity of the photons is unaffected. This results in the period of the clock remaining constant.
12. Accepting item 11 means there is no time dilation in a photon clock moving in empty space.
13. If ship A is our ‘stationary’ reference, the apparent slowing of clock B in ship B is an illusion.
14. If the ‘moving’ ship in these experiments in empty space decelerates and returns to rest beside the ‘stationary’ ship, both clocks will tick at the same rate and neither clock will have lost time relative to the other.
15. In empty space the apparent velocity of a process is dependent on the perspective of the observer.
16. The photon clock is a proxy for any process that takes time.
17. The assumption of an empty space yields the illusion of the reciprocity paradox.
18. The reciprocity paradox in an empty space cannot be resolved by a geometric analysis.
19. The reciprocity paradox in an empty space is an inviolable illusion.

Conclusions 3. Time Dilation Phenomena in a Space Containing a Medium that Supports the Propagation of Photons and Other Force Particles

1. A field termed the temporal-inertial (TI) field permeates space.
2. The TI field supports the propagation of photons and other force particles (except gravitons).
3. The TI field provides a reference for motion.
4. A process moving relative to the TI field takes longer than when the process is stationary relative to the TI field.
5. Velocity of a process relative to the TI field is the root cause of time dilation.
6. Acceleration of a process relative to the TI field does not cause time dilation other than through the velocity caused by the acceleration.
7. If two processes move relative to each other, at least one of them moves relative to the TI field.
8. In space permeated by particles of the TI field, the velocity of a process relative to the TI field is independent of the perspective of the observer.

9. If two processes move relative to the TI field, the velocity of each process must be considered in evaluating the difference in time dilation between the two processes, not just their difference in velocity. [5] [6]
10. Comparing the time dilation between two processes, the process with the greater velocity relative to the TI field experiences the greater time dilation and thus violates the reciprocity (twin) paradox.

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