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Time Dilation and the Twin Paradox Revisited

Abstract

Conventionally, time dilation is defined as the decrease in the rate of flow of time in a frame moving relative to an outside observer. I argue that any process (exemplified by, say, a clock) that moves through space takes longer than that process would take if that process were stationary relative to space. The space that I define in this context is a field (of particles as yet undefined) that I label the ***temporal-inertial (TI)*** field. The relation between the TI field and the Higgs field or Higgs fields is undefined in this conjecture. I argue that the TI field constitutes the one and only frame of reference for motion by which time dilation can be reckoned. Furthermore, the velocity of a process relative to the TI field is the one and only cause of time dilation for that process. Accordingly, time dilation is not a decrease in the rate of flow of time in a moving frame, but an increase in the time taken by a process in motion relative to the TI field. If we measure time by the cycle time of a process (e.g. the ticking of a clock) it doesn't mean that time slows down when the process is in motion, it means that the process takes longer when moving relative to the TI field. The twin paradox is readily resolved by reckoning the motion of the traveling twin relative to the space through which the twin (or clock) moves, not relative to the reference, stationary twin (or clock). The time dilation between two clocks moving in space is shown to be based on each clock's velocity relative to the TI field, not on the difference of their velocities relative to each other. The TI field is shown to be subject to gravity. Gravitational time dilation of a process (e.g. a clock) is shown to be caused directly by the velocity of the process relative to the TI field, not by the graviton flux at the process.

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^ Objectives of this Study

The ideas expressed in this study derive from work done in Reference [1]. Indeed, some of the content of this study is taken from this reference. We'll discuss time dilation between clocks and the twin paradox.

I deny the premise of Special Relativity that asserts that there is no privileged reference for motion. By now, we have begun to realize that 'space' is not empty. It teems with virtual particles, the Higgs field or fields, dark matter and dark energy. Most of this 'stuff' is unexplained by current theory. My conjectures are based on the assertion that a field (of particles as yet undefined) constitutes this privileged frame of reference for motion. Accepting this assertion means that time dilation and the twin paradox (which is an example of time dilation) must be based on motion (velocity) relative to the TI field, not relative to an arbitrary frame of reference. The following lists the objectives of this study.

- Show that contrary to the tenet of Special Relativity, there is a privileged frame of reference for motion and it is the TI field.
- Express time dilation as a function of velocity relative to the TI field, not to any arbitrarily chosen frame of reference.
- Justify the assertion that the TI field is subject to gravity.
- Show that gravitational time dilation is not caused directly by the flux of gravitons, but is mediated by the infall velocity of the TI field in the vicinity of a gravitational body.
- Show that gravitational time dilation is caused by the velocity of the TI field falling toward the gravitational body.
- Show that the expression for time dilation in a circular orbit, based on gravity, that was derived by Schwarzschild from General Relativity [2], and the expression provided by the infall velocity of the TI field are identical.
- Show that the comparison of the time dilation between two clocks moving in space must be based on each clock's velocity relative to the TI field, not on the difference of their velocities relative to each other.
- Show that the conundrum of the thought experiment of the twin paradox is readily resolved if motion of the traveling twin is reckoned relative to the TI field, not to the 'stationary' twin.

^ The Twin Paradox

The twin paradox arises in a thought experiment in which one twin travels at relativistic speed away from his sibling and returns some time later to find that his twin has aged more than he the traveler.

The paradox occurs because of the apparent reciprocity in the view of each twin that his sibling has aged more than he has during the experiment. In a universe without a fundamental frame of reference for motion, the motion of each twin relative to the other is equally valid in assessing the rate at which each twin ages. But in the experiment one twin ages, the other does not, or, rather, one ages more slowly than the other. How should one resolve the apparent discrepancy?

Conventional resolutions of the twin paradox are based on the difference in velocity between the two twins and the determination of which of the two twins accelerated during the journey. My disagreement with such explanations centers on the premise that the physics of the interaction with time can be reckoned to the velocity between the moving twin and his sibling who is stationary relative to an arbitrarily chosen frame of reference. Motion relative to an arbitrary frame does not explain the physics of how time dilation is produced by such motion [3].

^ Time Dilation

Time dilation is defined as the decrease in the rate of flow of time in a frame moving relative to an outside observer. Time dilation in the frame moving relative to an outside observer is given by Cutner [4]:

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

where

> t_2 / t_1 is the ratio of period t_2 measured by the moving clock with respect to the period t_1 measured by the clock of the outside observer.
>
> v_2 is the velocity of the moving clock relative to that of the outside observer.

Let me restrict the validity of Eq. (1) by requiring the clock of the outside observer, measuring the value of t_1, to be stationary relative to space, or more specifically in this conjecture, the TI field.

^ A Thought Experiment on the Twin Paradox

Clocks provide a better comparison of elapsed times than the aging of twins, but this example is applicable to the twin paradox.

Imagine two spaceships, A and B, located in space far away from any gravitational masses. The two ships contain identical, accurate clocks. The purpose of the experiment is to determine the effect of the motion of Ship B on the timekeeping of its clock compared with the ‘stationary’ reference clock in Ship A.

The experiment is conducted as follows:

- At the start of the experiment, the two clocks are set to read the same value.
- Initially, Ships A and B are located next to each other and are stationary relative to the TI field.
- Ship B accelerates away from Ship A.

- Ship B moves away from Ship A at relativistic speed for some time.
- Ship B then decelerates until its speed relative to Ship A is zero.
- Ship B remains at its midpoint stop for a short time.
- Ship B then accelerates up to relativistic speed back toward Ship A.
- Ship B decelerates and comes to a stop at the location of Ship A.
- The time on Clock B aboard Ship B is then compared with the reading of Clock A aboard Ship A.
- It is found that Clock B has lost time relative to Clock A.

What do we know about the relation between the motion of Ship B and the time ticked off by its clock?

- We know that when the two ships are stationary relative to each other, the two clocks tick at the same rate. This state occurs at three times; at the start of the experiment, when Ship B stops at the midpoint of its journey and at the end of the experiment when Ship B stops next to Ship A.
- We know that at the end of the experiment, the time measured by Clock B is less than that measured by Clock A. Clock B has lost time relative to Clock A.
- Consequently, we know that during the test, Clock B ran more slowly than Clock A.
- We know that as Ship B and Clock B sped away from Ship A and Clock A, the tick rate of Clock B decreased.
- We know that as Ship B decelerated and stopped relative to Ship A, the tick rate of Clock B increased so that when Clock B was stationary relative to Clock A its tick rate was the same as that of Clock A.
- We know that as Ship B and Clock B accelerated back toward Ship A, the tick rate of Clock B again decreased.
- We know that as Ship B decelerated and stopped next to Ship A, the tick rate of Clock B increased so that when Clock B was stationary relative to Clock A its tick rate was again the same as that of Clock A.

What can we conclude from this knowledge of the relationship between the tick rate of Clock B and its motion?

- The tick rate of Clock B is a function of its motion relative to Clock A.
- The faster Clock B moves relative to Clock A, the slower its tick rate.
- Increase the velocity of Clock B relative to Clock A and its tick rate decreases; decrease the velocity of Clock B and its tick rate increases.
- The changes in tick rate of Clock B are intrinsic and absolute; they are not merely changes observed from a distant, arbitrarily chosen reference point.

- At no time during the experiment did reference Clock A assert any influence on the tick rate of Clock B. Clock A served only to compare the elapsed time of the two clocks at the end of the experiment.
- Some entity in the immediate vicinity of Clock B must be responsible for the change of the clock's tick rate with its change in motion relative to Clock A.
- I assert that this entity is space itself, or more specifically, the TI field that permeates space. Recall the stipulation at the start of the experiment that Ship A was stationary relative to this TI field. Accordingly, all motion of Ship B relative to Ship A was also made relative to this same TI field.
- ***Contrary to the tenet of Special Relativity, there is a privileged frame of reference for motion and it is the TI field.***

Behavior of the clocks in our thought experiment is summarized in Table 1.

^ Table 1. Phases of Flight and the Effect on Clock Rate

Assumptions: Two accurate, identical clocks A and B are in Spaceships A and B, respectively. The period of Clock A is t_1. The period of Clock B is t_2. I use the period t_i between ticks of a clock to compare the two clocks, not the duration T_i of a phase of flight as in Eq. (2) through Eq. (6) in the section below. Ship A remains stationary relative to the TI field during the entire experiment. Label the velocity of Ship B relative to Ship A and the TI field as v_2 during all phases of the experiment. The value of v_2 varies during the experiment.
A. Setup: Clocks A and B in Ships A and B are synchronized to indicate the same time. Clock A serves as a reference.
B. Outbound Acceleration: Ship B accelerates away from Ship A. As Ship B accelerates away from Ship A the tick rate of its clock slows down. At any given moment during the acceleration, the period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $t_2 = \gamma * t_1$ where $\gamma = 1 / [1 - (v_2 / c)^2]^{1/2}$ In other words, Clock B is ticking slower than Clock A. Recognize that v_2 is changing during this phase, but at any given instant, the equations shown are valid.

C. Outbound Coast: Ship B maintains a velocity of v_2 relative to Ship A and the TI field. The period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $$t_2 = \gamma * t_1$$ $$\text{where } \gamma = 1 / [\ 1 - (v_2 / c)^2\ ]^{1/2}$$ In other words, Clock B is ticking slower than Clock A. The value of v_2 is constant during this phase.
D. Outbound Deceleration: Ship B slows its velocity away from Ship A until it is stationary relative to Ship A and the TI field. As Ship B slows down relative to Ship A and the TI field the tick rate of its clock speeds up. At any given moment during the deceleration, the period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $$t_2 = \gamma * t_1$$ $$\text{where } \gamma = 1 / [\ 1 - (v_2 / c)^2\ ]^{1/2}$$
E. Outbound Stop: When the velocity v_2 of Ship B relative to Ship A and the TI field is zero, its tick rate is the same as that of Clock A. Ship B refuels so that its mass is the same at the start of the inbound leg as that on the outbound leg.
F. Inbound Acceleration: Ship B accelerates back toward Ship A. As Ship B accelerates toward Ship A the tick rate of its clock again slows down. At any given moment during the acceleration, the period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $$t_2 = \gamma * t_1$$ $$\text{where } \gamma = 1 / [\ 1 - (v_2 / c)^2\ ]^{1/2}$$ In other words, Clock B is again ticking slower than Clock A.
G: Inbound Coast: Ship B maintains a velocity of v_2 relative to Ship A and the TI field. As before, the period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $$t_2 = \gamma * t_1$$ $$\text{where } \gamma = 1 / [\ 1 - (v_2 / c)^2\ ]^{1/2}$$

H. Inbound Deceleration: Ship B slows its velocity toward Ship A until it is stationary relative to Ship A and the TI field. As Ship B slows down relative to Ship A and the TI field the tick rate of its clock speeds up. At any given moment during the deceleration, the period t_2 of Clock B in Ship B is greater than the period t_1 of Clock A by the factor: $t_2 = \gamma * t_1$
I. Stop at Ship A: When the velocity v_2 of Ship B relative to Ship A and the TI field is zero, its tick rate and period are the same as those of Clock A.

^ Determine the Time Dilation of the Moving Clock

Can we determine the magnitude of the effect of motion on the clock in our thought experiment? Our experiment comprised several phases:

- Acceleration of Ship B and its clock to relativistic speed.
- Outbound coast phase away from Ship A at constant velocity.
- Deceleration of Ship B to a stop relative to Ship A.
- A short stay by Ship B at the midpoint of its journey.
- Acceleration of Ship B back toward Ship A.
- Inbound coast phase back toward Ship A at constant velocity.
- Deceleration of Ship B until it reaches a stop at Ship A.

Let's identify the duration, as measured by Clock B, of the acceleration phases of flight as T_{accel} and the duration of the coast phases of flight as T_{test}. The short stay at the midpoint of the trip is $T_{midpoint}$. Then at the end of the experiment, the elapsed time of flight measured by reference Clock A is given by:

$$T_{ref1} = K_1 * T_{accel} + T_{midpoint} + \gamma * T_{test1} \qquad (2)$$

where

K_1 = a time dilation factor relating the time on Clock B during the acceleration phases relative to the time elapsed on reference Clock A.

γ = the Lorentz factor $1 / [\ 1 - (v_2 / c)^2\ ]^{1/2}$

v_2 = the velocity of Ship B and Clock B relative to Ship A, Clock A and the TI field. (Recall that Ship A and Clock A are stationary relative to the TI field.)

c = the velocity of light

Now, let's perform a second experiment exactly like the first with the exception that both coast phases of flight of Ship B are double their values in the first experiment. The elapsed time of the second experiment as measured on reference Clock A is:

$$T_{ref2} = K_1 * T_{accel} + T_{midpoint} + \gamma * 2\ T_{test1} \qquad (3)$$

We can eliminate the time dilation during the acceleration phases of the experiment by subtracting the elapsed time on reference Clock A of the first experiment from that of the second.

$$T_{ref} = K_1 * T_{accel} + T_{midpoint} + \gamma * 2\ T_{test1} - [K_1 * T_{accel} + T_{midpoint} + \gamma * T_{test1}] \qquad (4)$$

$$T_{ref} = \gamma * T_{test1} \qquad (5)$$

The ratio of T_{ref} to T_{test1} = yields:

$$T_{ref} / T_{test1} = \gamma = 1 / [\ 1 - (v_2 / c)^2\ ]^{1/2} \qquad (6)$$

where, as before

v_2 is the velocity during the coast phases of the experiment of Ship B and Clock B relative to Ship A, Clock A and the TI field.

By conducting the experiment as we have, we've eliminated the need to account for time dilation during the acceleration phases of flight. I don't mean to imply that acceleration causes time dilation; only that the velocity at any moment during the acceleration phases does. We refueled Ship B at the midpoint of the test so that the acceleration profiles of the inbound and outbound flights were the same and could be eliminated from the calculations by simple subtraction.

The result of our thought experiment, expressed in Eq. (6), confirms that the time dilation measured by the two clocks is a function of the velocity ***relative to the TI field*** of the moving Clock B.

^ The Temporal-Inertial (TI) Field is the Fundamental Frame of Reference for Motion

It is clear from our thought experiment that a change in velocity of Ship B and Clock B relative to 'some frame of reference' in space produces a change in the tick rate of the clock. The ratio between the elapsed time of the moving clock and Clock A, that is stationary relative to this frame of reference, is shown in Eq. (6) to be a function of the velocity relative to this frame of space of the moving clock. The question is what comprises the frame of reference of space? The term frame is a mathematical concept, such as a coordinate system, by which to reckon position and motion of physical objects, not in itself a physical entity. A physical entity such as a field must constitute this frame.

The difference in time measured between the moving and stationary clocks is not merely an appearance wrought from the mathematics of frames moving relative to one another and the finite speed of light. Such a construct is the essence of the so-called twin paradox. Conventionally, this paradox is resolved by determining which twin accelerates in the scenario. In contrast, the thesis of this paper resolves the paradox by determining the velocity of the moving twin relative to the aforementioned field of space, not relative to the stationary twin. The traveling astronaut really does age more slowly than his stay-at-home twin.

The difference in time measured between moving and stationary clocks is intrinsic and absolute. A moving clock really does tick more slowly than its stationary counterpart. We can safely conclude that if the velocity of a clock relative to this field of space causes a change in the timekeeping of the clock then there is an interaction between the timekeeping process of the clock and its velocity relative to this field.

I assert that a field that I label the TI field constitutes this frame of reference for motion. Whether this field is one of the Higgs fields or some 'other field' is not relevant to this discussion. I give this field the name temporal-inertial field because of its role in time dilation and the inertial interaction. The inertial interaction is not discussed in this paper.

^ The Clock is Representative of a Process

A process is a change or sequence of changes that takes time. We use a clock as representative of a process that also measures the time taken by the process. I take exception to the notion that time dilation is the decrease in the rate of flow of time in a frame moving relative to an outside observer. I assert that the passage of time is constant everywhere, but that a process that moves relative to the TI field takes longer than if the process were stationary relative to the TI field. The process can be atomic, such as the emission of light from an atom; chemical such as the reaction of oxidation or biological such as the aging of an astronaut. The rate at which any process proceeds depends solely on its velocity through the TI field not on its velocity relative to an arbitrarily chosen frame of reference. Accordingly, the twin paradox is resolved, just as our thought experiment with the two clocks, when the motion of the moving twin is reckoned relative to the TI field not to the frame of reference of the stationary twin.

^ Motion Through Space is the Root Cause of Time Dilation

We now examine the behavior of two identical clocks each of which moves relative to the TI field to determine the effect of such motion on the timekeeping of the two clocks.

The purpose of this section is threefold:

- Show that contrary to the tenet of Special Relativity, there is a privileged frame of reference for motion and it is the TI field.
- Express time dilation as a function of velocity relative to the TI field, not to any arbitrarily chosen frame of reference.
- Show that the comparison of the time dilation between two clocks moving in space must be based on each clock's velocity relative to the TI field, not on the difference of their velocities relative to each other.

This section is taken in its entirety from Reference [1].

It's a logical conclusion from the previous thought experiment that any motion relative to the TI field causes time dilation. ***Accordingly, motion relative to the temporal-inertial field, not just relative to another frame of reference, must be included in evaluating the time dilation of a moving object***.

To support the assertion of the highlighted sentence above, continue our thought experiment, but ignore the caveat that Ship A is stationary relative to the TI field. Let Ship A move with velocity v_1 relative to the TI field. We may let the TI field itself be our frame of reference, because this is, after all, a thought experiment. Let Ship B move at velocity v_2 relative to the TI field. For simplicity, assume that v_2 is in the same direction as v_1 and is greater than v_1. Both clocks will now experience time dilation in accordance with Eqs. (7) and (8).

$$t_1 / t_0 = 1 / (1 - v_1^2 / c^2)^{1/2} \quad (7)$$

$$t_2 / t_0 = 1 / (1 - v_2^2 / c^2)^{1/2} \quad (8)$$

where

t_0 is the period of a third clock that is stationary relative to the TI field.

t_1 is the period of Clock A in Ship A.

t_2 is the period of the Clock B in Ship B.

v_1 is the velocity of Ship A and Clock A relative to the TI field.

v_2 is the velocity of Ship B and Clock B relative to the TI field.

t_1 / t_0 is the ratio of period t_1 measured by Clock A relative 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 relative 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. (8) by Eq. (7):

$$t_2 / t_1 = (1 - v_1^2 / c^2)^{1/2} / (1 - v_2^2 / c^2)^{1/2} \tag{9}$$

Compare the result of Eq. (9) with that of Eq. (1) repeated below:

$$t_2 / t_1 = 1 / (1 - v_2^2 / c^2)^{1/2}$$

These two expressions equate only if v_1 in Eq. (9) is zero, that is, only if Clock A measuring t_1 is stationary relative to the TI field.

If the difference in time dilation between the two moving clocks were based on the difference in velocity between them the expression would be

$$t_2 / t_1 = [1 - (v_2 - v_1)^2 / c^2]^{1/2} \tag{10}$$

or

$$t_2 / t_1 = [1 - (v_2^2 - 2v_1v_2 + v_1^2) / c^2]^{1/2} \tag{11}$$

Clearly, Eq. (11) is not the same as Eq. (9).

Let me summarize the meaning of the foregoing arguments:

- The TI field is the absolute reference frame for motion of particles or objects in the field.
- Time dilation of an object moving in space is a function of its velocity relative to the TI field. The faster a clock moves relative to theTI field, the greater is its period and the slower its clock ticks.
- Comparison of the time dilation between two clocks moving in space must be based on each clock's velocity relative to the TI field as expressed in Eq. (9), not on the difference of their velocities relative to each other.

The contention that any calculation of time dilation of a moving object must include its velocity relative to the TI field is supported.

^ Gravitational Time Dilation

The purpose of this section is twofold:

- Show that gravitational time dilation is not caused directly by the flux of gravitons, but is mediated by the infall velocity of the TI field in the vicinity of a gravitational body.
- Show that gravitational time dilation is caused by the velocity of the TI field falling into the gravitational body.

Schutz [5], p.286 expresses the dilation of time in a gravitational field:

$$t_2 / t_1 = 1 / (1 - 2GM / Rc^2)^{1/2} \qquad (12)$$

where

t_1 is the period of a clock located where there is no gravitational influence.

t_2 is the period of an identical clock measured at a distance R from a gravitational mass M.

t_2 / t_1 represents the time dilation caused by the gravitational field at a distance R from the center of the mass M.

Now, I'll compare the expression of Eq. (12) with one derived based on the infall velocity of particles of the TI field in response to gravity. The escape velocity of a particle from a distance R from the center of a spherical body such as a planet or star with a mass M can be determined by equating the kinetic energy of the particle with its gravitational potential [6], p282:

$$1/2\, v_{escape}^2 = GM / R \qquad (13)$$

The escape velocity is then

$$v_{escape} = (2GM / R)^{1/2} \qquad (14)$$

Remembering that in Eq. (14) R is the distance from the center of the gravitational body and is greater than the radius of the body itself.

Substituting the value of v_{escape} in Eq. (14) for v_2 in Eq. (1) gives:

$$t_2 / t_1 = 1 / (1 - 2GM / Rc^2)^{1/2} \qquad (15)$$

where

t_2 / t_1 represents the time dilation caused by the gravitational field at a distance R from the center of the mass M.

Equation (15) is identical to Eq. (12). Does the appearance of the value of the escape velocity in the expression for gravitational time dilation suggest another mechanism at work? The conjecture asserts that it does and it is this: gravitation does not cause time dilation directly, but does so only through its acceleration of the TI field.

More clearly, substitute Eq. (14) into Eq. (15) and express gravitational time dilation in terms of the escape velocity at a given radius from the gravitational body:

$$t_2 / t_1 = 1 / (1 - v_{escape}^2 / c^2)^{1/2} \tag{16}$$

^ Argument in Favor of the TI Field Being Subject to Gravity

We examine the behavior of a clock (representative of any process) in four circumstances and draw two conclusions:

- The TI field is subject to gravity.
- The time dilation measured by the clock is caused not directly by graviton flux at the clock but by the velocity of the TI field as it falls toward the center of the gravitational body in its own response to gravity.

Consider the behavior of the clock in four circumstances:

- ***The TI Field is Not Subject to Gravity. The Clock Rests on the Surface of the Gravitational Body***

  If the TI field is not subject to gravity there is no motion of the clock relative to the TI field. The only mechanism that could produce time dilation is the flux of gravitons at the clock. However, as argued below, graviton flux does not directly cause time dilation at the clock.

- ***The TI Field is Not Subject to Gravity. The Clock is in Free Fall Toward the Gravitational Body***

  The falling clock is exposed to graviton flux. However, there is no time dilation in a freely falling frame [6]. Accordingly, time dilation is not caused by graviton flux. If the TI field is not subject to gravity, time dilation would be caused by the velocity of the clock falling relative to the TI field. However, again, the falling clock does not experience time dilation. The TI field must therefore be subject to gravity and accelerates at the rate in accord with Newton's law of gravitation applied not to a conventional mass, but to particles of the TI field.

- ***The TI Field is Subject to Gravity. The Clock Rests on the Surface of the Gravitational Body***

  Time dilation is caused by the infall velocity of the TI field. The infall velocity of the TI field is equal, but opposite in sign to the escape velocity at any radius from the gravitational body. As discussed in the next subsection, graviton flux at the clock does not cause time dilation.

- ***The TI Field is Subject to Gravity. The Clock is in Free Fall Toward the Gravitational Body***

  The falling clock is exposed to the flux of gravitons, but does not experience time dilation. (There is no redshift in a freely falling frame.) Any difference in acceleration by the clock relative to the TI field would produce a force on the clock to decrease the relative acceleration. The clock thus accelerates at the same rate as the TI field and its velocity relative to the TI field does not change.

  Time dilation is not experienced by the clock because, again, its velocity relative to the infalling TI field does not change.

  This proposition is discussed more fully in the Section 'A Falling Clock Loses No Time'.

These arguments are summarized in Table 2.

^ Table 2. Arguments on the Cause of Gravitational Time Dilation

A. *The TI field is not subject to gravity.* A clock rests on the surface of the gravitational body.
Time dilation would be caused by the graviton flux at the clock if that phenomenon were real, but as argued below, it is not. Some other phenomenon must be responsible for time dilation of the clock at rest on the surface of the gravitational body.
B. *The TI field is not subject to gravity.* A clock is in free fall toward the gravitational body.
There is no time dilation in a freely falling frame. Accordingly, time dilation is not caused by graviton flux. Time dilation would be caused by the velocity of the falling clock relative to the TI field. ***The falling clock does not experience time dilation. If the TI field is not subject to gravity, time dilation would be caused by the velocity of the clock relative to the TI field. The TI field must therefore be subject to gravity.***
C. *The TI Field is subject to gravity.* A clock rests on surface of the gravitational body.
Time dilation is caused by the infall velocity of the TI field. The infall velocity of the TI field is equal, but opposite in sign to the escape velocity at any radius from the gravitational body.
D. *The TI Field is subject to gravity.* A clock is in free fall toward the gravitational body.
Time dilation is not measured by the clock because its velocity relative to the infalling TI field does not change and time dilation is not caused by graviton flux.

^ A Falling Clock Loses No Time

This section is taken in its entirety from Reference [1].

An example consistent with relativity and the conjecture that the TI field falls radially toward the Earth is that of an object falling radially toward the Earth in the absence of air resistance. A clock dropped straight toward the center of a gravitational mass (say the Earth) will accelerate with the TI field itself and consequently will not change velocity relative to the field. Accordingly there will be no change in time dilation during its descent. The clock's velocity as it falls will be its initial velocity plus its acceleration, g, (as mediated by the TI field) times the time of the fall.

$$v_{clock} = v_{clock0} + gt \tag{17}$$

where

v_{clock} = velocity of the clock as it falls toward the gravitational body

v_{clock0} = velocity of the clock relative to the gravitational body when it's released

The velocity of the infall of the TI field at the location of the clock will be

$$v_{TI} = v_{TI0} + gt \tag{18}$$

where

v_{TI} = velocity relative to the gravitational body of the TI field at the location of the clock

v_{TI0} = velocity relative to the gravitational body of the TI field at the point where the clock is released

The velocity of the clock relative to the TI field of space as it falls remains constant and is

$$v_{clock} - v_{TI} = v_{clock0} + gt - (v_{TI0} + gt) = v_{clock0} - v_{TI0} \tag{19}$$

Thus, during its fall the clock will retain the same period it had when it started its descent. The ratio of this period to that of a distant clock is expressed by Eq. (15) and Eq. (16).

The clock's period will change to the value of its rest position when it stops at the surface of the gravitational mass. (It will tick more slowly than when it started its descent.) This behavior is in accord with Schutz's [6], p115 analysis and conclusion that "there is no redshift in a freely falling frame." The conjecture of the infall of the TI field toward the Earth is consistent with this example.

^ Time Dilation in a Circular Orbit

The purpose of this section is to show the identity of the expression for time dilation in a circular orbit (derived by Schwarzschild from General Relativity [2]) with the expression based on the infall velocity of the TI field. Time dilation of a clock in a circular orbit about a gravitational body is given by Reference [2].

$$t_2 / t_1 = 1 / (1 - 3GM / Rc^2)^{1/2} \tag{20}$$

where

t_1 is the period of a clock located beyond the effect of any gravitational body,

t_2 is the period of a clock in a circular orbit,

G is the gravitational constant,

M is the mass of the gravitational body being orbited,

R is the radius of the circular orbit,

c is the speed of light.

In general, time dilation of a clock moving through space at velocity v_2 is given by Eq. (1) repeated below as Eq. (21).

$$t_2 / t_1 = 1 / (1 - v_2^2 / c^2)^{1/2} \tag{21}$$

Persevering with our belief that velocity of a clock relative to the TI field is the only cause of time dilation, we calculate the combined effects of the orbital velocity and the infall velocity of the TI field at the location of the orbiting clock.

Combine the orbital velocity [7] and the infall velocity to yield the formula for gravitational time dilation in a circular orbit.

$$v_{orbital} = (GM / R)^{1/2} \tag{22}$$

The magnitude of the infall velocity is equal to the escape velocity at a given radius from the gravitational body. From Eq. (14),

$$v_{infall} = (2GM / R)^{1/2} \tag{23}$$

The orbital and infall velocities are orthogonal, so they may be added using the Pythagorean Theorem:

$$v_{total}^2 = v_{orbital}^2 + v_{infall}^2 \tag{24}$$

$$v_{total}^2 = 3GM / R \tag{25}$$

Substituting the value of v_{total}^2 in Eq. (25) for v_2 in Eq. (21) yields

$$t_2 / t_1 = 1 / (1 - 3GM / Rc^2)^{1/2} \tag{26}$$

Equation (26) expresses the time dilation of a clock in a circular orbit based on combining its orbital velocity with the infall velocity of the TI field. Equation (26) is identical with Eq. (20) that expresses the time dilation of a clock in a circular orbit derived by Schwarzschild from General Relativity [2]. The gravitational force acts through the intermediary of the acceleration of the TI field. The acceleration and resultant velocity of the TI field results from the gravitational force on particles of the field. Equation (26) argues that the immediate cause of the time dilation experienced by the orbiting clock is the combination of orbital velocity of the clock and the infall velocity of the TI field at the clock.

^ Comparison of the Time Dilation of an Object in Free-Fall Toward the Center of a Gravitational Body with that of an Object in a Circular Orbit About the Gravitational Body

The title of this section is perhaps misleading; an object (a clock or any process) in a circular orbit about a gravitational body is free-falling, but its velocity relative to the TI field about the gravitational body is quite different from that of an object free-falling directly toward the center of the body.

The velocity of an object in free-fall toward the center of a gravitational body does not change relative to the TI field. The TI field and the body both accelerate at the same rate. Consequently, there is no time dilation experienced by the object (say a clock).

The velocity of an object in a circular orbit about a gravitational body, relative to the TI field, is a combination of the orbital velocity of the object and the infall velocity of the TI field at the object. The object (say a clock) thus experiences time dilation in accord with its velocity relative to the TI field in accord with Eq. (26).

^ Conclusions

1. The TI field provides an absolute reference frame for motion.
2. Time dilation of an object moving in space is a function of its velocity relative to the TI field. The faster a clock moves relative to theTI field, the greater is its period and the slower its clock ticks.
3. Time dilation in a moving frame is a function of the velocity of that frame relative to the TI field.
4. Time dilation of a moving particle or object composed of particles is intrinsic, absolute and not dependent on the observation of an outside observer.
5. The ratio of time dilation experienced by two moving clocks is a function of each clock's velocity relative to the TI field, and is not a function of their velocity relative to each other.
6. Time dilation of a clock (or any process) is zero when the clock is stationary relative to the TI field.
7. The corollary to Item 6 is that the tick rate of a clock is maximum when the clock is stationary relative to the TI field.
8. The clocks in this thought experiment are representative of any time consuming process, whether subatomic, atomic, chemical or biological.
9. Gravitational time dilation is not caused directly by the flux of gravitons, but is mediated by the infall velocity of the TI field in the vicinity of a gravitational body.
10. Gravitational time dilation is caused by the infall velocity toward a gravitational body of the TI field relative to an object (clock or process) within the field.
11. The velocity of an object (clock or process) in a circular orbit about a gravitational body, relative to the TI field, is a combination of the orbital velocity of the object and the infall velocity of the TI field at the object. The object (say a clock) thus experiences time dilation in accord with its velocity relative to the TI field.

^ References

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