the general science journal

Time dilation between frames inside and outside gravitational fields

True Relativity Part II

Abstract

This paper is based on the theory of True Relativity and only uses simple geometry to calculate time dilation between frames inside gravitational fields and free space. The premiss of this paper is that only a force that is unbalanced acting on an object such as acceleration will cause time dilation.

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Time dilation on a non-rotating body

The contention of True Relativity[1] is that every particle or object in this Universe generates its own volume of spacetime field around itself. The size of the spacetime field will be dependant on the objects mass and whether or not it is acted on by an unbalanced force such as inside a gravitational field or under acceleration. Time dilation is not caused by velocity as stated by Einstein according to TR but by any force that is unbalanced such as acceleration on the object or particle in question. Any unbalanced force on the object will cause time to dilate because the spacetime field will begin to collapse. The reason is the collapse of the objects spacetime field is due to the displacement from the centre of that field when an object or particle has the unbalanced force acting on it, in other words when it is under acceleration. Therefore the equivalence principle is very much a part of True Relativity and I am also in complete agreement with Einstein that gravity itself is a distortion of spacetime.

The most famous experiment involving time dilation was probably the one by Hefele and Keating undertaken in October of 1971. The experiment involved the use of atomic clocks. One placed at the United States Naval Observatory another four clocks were placed on scheduled aircraft and flown twice around the world, some heading east and the others heading west.

It was predicted from Einstein's Relativity that the clocks moving in the easterly direction would gain time compared to the clock at the observatory. It is this experiment that physics uses as proof that time dilation is real. When the raw data was released Dr Kelly said the data was averaged in a biased way in order to claim such high precision while the inventor of the atomic clock, Louis Essen, pointed out the inadequate accuracy of the experiment.

No experiment where acceleration is the only cause of time dilation has ever been undertaken by the physics community because since Einstein it has always been believed that velocity is mainly responsible for time dilation. Gravitational time dilation in GR, derived from the Schwarzschild metric, for a non-rotating body is given as

$$t = t' \cdot \sqrt{1 - \frac{2 \cdot G \cdot M}{r \cdot c^2}} \qquad (1)$$

Where t = the value for the second of an object considered in free space as viewed from the frame on the non-rotating body, t′ = proper time on the non-rotating body, G = Newton's universal gravitational constant, M = mass of the non-rotating body, r = distance from the non-rotating body's centre of mass, c = velocity of light in a vacuum.

Whilst it is believed that equation (1) is the definitive equation for time dilation between a frame considered in free space and a frame inside a gravitational field on a non-rotating body, TR contends that this is not the case and Einstein may be wrong. From the point of view of TR it is only when an object experiences an unbalanced force when it is under acceleration that accounts for time dilation. Velocity is not a force and plays no part in time dilation because space is not considered as a metric in this concept of three dimensional spacetime. There is time dilation caused by the finite velocity of light in a vacuum but it is not the velocity itself that causes time dilation. According to TR the amount of time dilation caused by acceleration can be verified by a simple time dilation experiment using two atomic clocks and a centrifuge.

There is disagreement between Einstein's value and TR's value for time dilation between frames inside and outside gravitational fields. The math of TR required calculating time dilation between two frames inside a gravitational field is based on simple geometry.

To find the time dilation between two frames immersed in a gravitational field on a non-rotating body, the displacement of an object caused by the gravity field in each frame has to found to enable the rate of time dilation between the frames to be determined.

The values given for the second will be accurate providing the STC has been calculated from experimental drop test data as explained in [1]. Initial calculation of the STC shows it to have a value of STC $\approx 4.192773 \times 10^{-10}$ kg^{-1} m^3.

Time dilation can be determined without the use of Newtonian physics using the TR equation from [1] to find the rate of displacement in each frame.

$$s = r - \frac{1}{2} \cdot \left[3 \cdot \frac{2}{\pi} \cdot \left[\left(\frac{4 \cdot \pi \cdot r^3}{3 \cdot \Phi} \right) \cdot \Phi - M \cdot STC \right] \right]^{\frac{1}{3}}$$

$$s' = r' - \frac{1}{2} \cdot \left[3 \cdot \frac{2}{\pi} \cdot \left[\left(\frac{4 \cdot \pi \cdot r'^3}{3 \cdot \Phi} \right) \cdot \Phi - M \cdot STC \right] \right]^{\frac{1}{3}} \qquad (2)$$

Where s = displacement in (m) in fame A, s′ = displacement in (m) in frame B, r = radius in (m) from the centre of mass of the non-rotating body in frame A, r′ = radius in (m) from the centre of mass of the non-rotating body in frame B, M = mass in (kg) of the non-rotating body and

STC = the spacetime constant from [1] in (kg^{-1} m^3), $\Phi = 4/3\pi R^3$ in (m^3) where R = 299792458 m.

If each frame is immersed at different depths inside the gravitational field they will view the amount of time dilation between them slightly differently because their value for the second will also be slightly different. The two simple TR equations shown in (3) and (4) will give the value for each second as viewed from the opposite frame thus equation (3) will give the value for the second in frame B as viewed from frame A.

$$sec' = \frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot(R-(s-s'))^3 \qquad (3)$$

Where sec′ = value for the second of frame B as viewed from frame A. By reversing the rates of displacement it is possible to calculate the value of the second in frame A as viewed from frame B as shown in equation (4).

$$sec = \frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot(R-(s'-s))^3 \qquad (4)$$

Time dilation on a rotating body

A rotating body such as the Earth introduces another unbalanced force in the form of centripetal acceleration. This force is in the opposite direction to the gravitational force and centripetal displacement is subtracted from the displacement caused by the gravitational field. To find the value for the second of frame B as viewed from frame A we can use equation (5).

$$sec' = \frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot\left[R-\left[\left(s-\frac{1}{2}\cdot\frac{\upsilon^2}{r}\right)-\left(s'-\frac{1}{2}\cdot\frac{\upsilon'^2}{r'}\right)\right]\right]^3 \qquad (5)$$

Where sec′ = the value for the second of frame B as viewed from frame A, ν = velocity in ($m\ s^{-1}$) of frame A on the surface of the rotating body, r = radius in (m) of the circle travelled by frame A, ν′ = velocity in ($m\ s^{-1}$) of frame B on the surface of the rotating body, r′ = radius in (m) of the circle travelled by frame B.

If we switch the displacements then the value for the second in frame A as viewed from frame B can be calculated as shown in equation (6)

$$sec = \frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot\left[R-\left[\left(s'-\frac{1}{2}\cdot\frac{\upsilon'^2}{r'}\right)-\left(s-\frac{1}{2}\cdot\frac{\upsilon^2}{r}\right)\right]\right]^3 \qquad (6)$$

Time dilation between a frame in the gravitational field and free space

Objects that have no unbalanced force acting on them can be considered as being in free space and time dilation between frames in free space and those inside a gravitational field of a non-rotating body can be found using a very simple TR equation.

Here frame A is in free space and frame B is on a non-rotating body

$$sec = \frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot(R-s')^3 \qquad (7)$$

Where sec = the value for the second of frame A in free space as viewed from frame B, R = 299792458 m and s′ = the displacement in (m) in frame B on the surface of the non-rotating body.

Equation (8) will give the value for the second of frame B on the surface of the non-rotating body as viewed by frame A in free space which will be the inverse of equation (7)

$$sec' = \frac{1}{\frac{1}{\Phi}\cdot\frac{4}{3}\cdot\pi\cdot(R-s')^3} \qquad (8)$$

Conclusion

Time dilation can be calculated between any frames using TR providing the displacement of an object due to the gravitational field is known in each frame.

It is the unbalanced force on an object that causes the spacetime field to collapse and time to dilate. In free space where there is no unbalanced force acting on the frame, a clock will beat at its fastest rate and can be considered as a Universal clock.

Time dilation between any two clocks on Earth and clocks in free space can be accurately calculated using the method described in this paper.

Reference

[1] T. Stanton. *True Relativity a theory of three dimensional spacetime*.. (available at http://www.wbabin.net)