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Article

# Experiments Conducted to Date to Verify the Relativistic Gravitational Time Dilation Have Limited Scientific Significance

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**Abstract** Experiments conducted to date to verify the relativistic gravitational time dilation have limited scientific significance because the basic postulate of Einstein's relativistic GR that the same time ( $t_0$ ) is measured in all non-inertial frames of reference, because all non-inertial frames of reference must be equal, has not yet been verified by time measurements. According to Einstein's relativistic GR, a correlation between time and different gravitational potentials must be the result of a relative relation between non-inertial frames of reference and must not be the result of any other physical influence. An experiment that can differentiate between a causal correlation (relative relation) and an apparent correlation (relativistic relation) between time and gravitational potentials is still outstanding. The expressions "relative" and "relativistic" are often used as synonyms. However, Einstein's GR is a relativistic theory. In the case of general relativity, relativistic means that time depends only on the relative relation between non-inertial frames of reference and not on other physical factors. The author proposes an easy-to-realize experiment that is able to distinguish between a causal correlation (relative relation) and an apparent correlation (relativistic relation) between time and gravitational potentials, which can confirm or falsify Einstein's relativistic GR.

**Keywords:** General relativity (GR); gravitational time dilation; gravitational red shift

## 1. Introduction

Einstein's relativistic physics postulates two conditions for time: 1. In all inertial frames of reference (SR) and in all non-inertial frame of reference (GR) the time measured must be constant (equal) because all inertial and non-inertial frames must be equal. 2. When we compare a clock with another clock in relative motion, time must pass relatively slower in the moving clock (SR). When we compare clocks within different gravitational potentials, time must pass relatively faster in the clock within a weaker gravitational potential than in the clock within a stronger gravitational potential. So far only experiments have been carried out, which could confirm a relative relation between time and different gravitational potentials, but not a relativistic relation between time and different gravitational potentials.<sup>1,2,3</sup> According to Einstein's relativistic GR, the same time ( $t_0$ ) is measured at any location within gravitational fields because all non-inertial frames must be equal. This means that there is a fundamental difference between a relative and a relativistic relation between time and different gravitational potentials. A relativistic relation between time and different gravitational potentials must, according to Einstein's relativistic GR, be the result of a relative relation between non-inertial frames of reference, so that a causal correlation between time and gravitational potentials is excluded. An experimental evidence of a correlations between time and gravitational potentials can be a causal or an apparent correlation. The author proposes an easy-to-realize experiment that can confirm or falsify GR, which postulates that clocks in all non-inertial frames of reference measure the same time  $t_0$  (proper time) because all non-inertial frames of reference are equal.

## 2. Proposal for a simple experiment that can verify or falsify a relativistic relation (apparent correlation) between time and gravitational potentials.

To conduct an empirical experiment that can distinguish between a relativistic and a relative relation between time and gravity we just need a difference in height, for example by using a tower, two atomic clocks of exactly the same type, one at the bottom of the tower and one at the top of the

tower, and a start-stop unit that is positioned at the same distance between the two atomic clocks, which is able to start and stop both atomic clocks via a radio signal. The two atomic clocks must be in a non-transparent box with a constant temperature inside the box and must not be connected with each other, so that a comparison of the measured time isn't possible during the measurement process. Let's for example use the tower of Mole Antonelliana in Turin for our experiment. Turin is 240 m above sea level, the viewing platform is 70 m higher and can be reached via an elevator. The atomic clocks shall have an accuracy of  $10^{-14}$  seconds. One atomic clock is positioned on the ground, the other atomic clock on the height of the viewing platform. A start-stop device is positioned at the same distance between the two atomic clocks, which can start and stop the time measurement of the atomic clocks via a radio signal. Since the deviation of one or two seconds at the beginning or end of the time measurement is not important because both atomic clocks will start and stop counting time at the same time, the accuracy of a normal radio-controlled clock at the start-stop device is sufficient. Because both clocks will measure time from zero, they do not need to be synchronized, which simplifies the experiment. At 12 a. m. on any Sunday of the year a random person, who doesn't know details about the experiment, is asked to press the start button between the clocks, so that both atomic clocks start counting the time from zero at the same time. At 12 a. on the following Sunday another random person, who doesn't know details about the experiment, is asked to press the stop button between the clocks, so that both atomic clocks stop counting the time at the same time. If we compared the two atomic clocks during the measurement process, according to Einstein's relativistic GR, after 7 days we would expect a time difference of approximately  $4.6 \times 10^{-9}$  s. For calculating the gravitational time dilation on Earth we can instead of  $\Phi/c^2$  use the following simplified equation, where  $\Phi$  is the gravitational potential,  $c$  the speed of light,  $G$  the gravitational constant,  $M$  the mass of Earth,  $r$  the radial distance from the center of Earth and  $m$  a mass within Earth's gravitational field:

$$\frac{\Phi}{c^2} = \frac{GM \times m}{r \times c^2} \approx \frac{g \times h}{c^2} \quad (1)$$

From equation (1) we calculate a difference between the time measured by an atomic clock at the bottom of the tower Mole Antonelliana  $t_B$  and an atomic clock on the viewing platform  $t_P$ , where  $\Delta h$  is 70 m:

$$\begin{aligned} \Delta t_P &= \frac{g \times (+\Delta h)}{c^2} \times t_B \\ \Delta t_P &= + \frac{9.8 \times \text{m} / \text{s}^2 \times 70\text{m}}{c^2} \times (7 \times 24 \times 60 \times 60)\text{s} \\ \Delta t_P &= + \frac{9.8 \times \text{m} / \text{s}^2 \times 70\text{m}}{c^2} \times 604800\text{s} = +4.6 \times 10^{-9} \text{s} \end{aligned} \quad (2)$$

However, because the atomic clocks cannot compare the time they measure during the measurement process, according to Einstein's relativistic GR, they must not measure a time difference because all non-inertial frames must be equal. When the atomic clocks don't show a time difference (within the scope of measuring accuracy) they have measured the same proper time ( $t_0$ ) and Einstein's relativistic physics is verified. In this case the correlation between time and gravitational potentials is only an apparent correlation (relativistic relation), indirectly caused by a relative relation between non-inertial frames of reference. However, when the clocks have measured a time difference of about  $4.6 \times 10^{-9}$  s, the result would have proofed a causal correlation between time and the strength of gravitational potentials (relative relation). This would mean that Einstein's relativistic physics has been falsified because time would not be constant in all non-inertial frames. In this case we would have to explain the gravitational time dilation with an alternative non-relativistic theory of relativity, which is able to explain a causal correlation between time and the strength of gravitational potentials.

### 3. Conclusions.

Experiments conducted to date to verify the relativistic gravitational time dilation have limited scientific significance. An experiment that can differentiate between a causal correlation (relative relation) and an only apparent correlation (relativistic relation) between time and gravitational potentials is still outstanding. According to Einstein's relativistic GR, the same time ( $t_0$ ) is measured at any location within gravitational fields because all non-inertial frames must be equal. This means that a measured relative relation between time and gravitational potentials must be the result of a relative relation between non-inertial frames of reference and must not have a causal correlation between time and gravitational potentials. In order to prove a relativistic relation (apparent correlation) between time and gravitational potentials, we have to measure time at different gravitational potentials in an experimental set-up that excludes a comparison of the measured time during the measurement process in atomic clocks. The author proposed an easy-to-realize experiment that can confirm or falsify Einstein's GR, which should be carried out urgently in this or a similar way, if we are seriously interested in checking Einstein's relativistic physics.

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