# The Reality of Time Dilation

Edward G. Lake*

*Independent Researcher*

Racine, WI USA

(Dated: October 16, 2017)

**Abstract**

Time Dilation has been repeatedly confirmed via experiments to be a real, natural phenomenon which can be easily demonstrated and verified in any laboratory capable of obtaining two sufficiently accurate atomic clocks. Yet, many physicists insist on viewing Time Dilation as nothing more than an "illusion," a solution to a mathematical problem which has no meaning without the problem. Understanding that Time Dilation is a real, natural phenomenon is the "key" to understanding and resolving some of the greatest mysteries in science, and also to correcting some of the greatest misunderstandings in science.

*Sole Author - Email: detect@outlook.com

## I. TIME DILATION EXPERIMENTS

In his 1905 paper *On the Electrodynamics of Moving Bodies*[(1)] Albert Einstein explained that Time Dilation (the slowing of time) was the solution to serious scientific problems related to Relativity and simultaneity that had been plaguing other scientists for many years. He described Time Dilation as a real, natural phenomenon in our real universe that can be mathematically measured and optically observed. Unfortunately, he failed to point out that Time Dilation may be best understood as a natural phenomenon all by itself, without all the complexities of the problems it solved.

In the past 100 years and more, Time Dilation has been repeatedly demonstrated and confirmed to be a real, natural phenomenon. Time actually does slow down for an object when the object is moving or when it gets closer to a gravitational mass. Perhaps the best known and most common demonstration we have today of how Gravitational and Velocity Time Dilation affect an object is what happens to clocks aboard GPS satellites. Each of the 30 or so GPS satellites orbits the Earth at a velocity of 13,964.4 kilometers per hour. At that velocity, time and the atomic clocks aboard the satellites run **slower** than atomic clocks on the ground by 7 microseconds (millionths of a second) per day, a fact predicted by Einstein's Theory of **Special** Relativity. Meanwhile, each of those satellites also orbits at an altitude of 20,184 kilometers above sea level. At that altitude, the atomic clocks aboard the satellites run **faster** than atomic

clocks on the ground by 45 microseconds per day, a fact predicted by Einstein's Theory of **General** Relativity. As a result, the atomic clocks aboard each of the GPS satellites were modified **before launch** to run 38 microseconds per day (45-7=38) **slower** than ground clocks, so that when they are in orbit, they will be **synchronous** with ground clocks. Otherwise the whole GPS system would become totally worthless in a matter of days.[(2)]

Perhaps the best and most important demonstration of the reality of Gravitational Time Dilation was performed by the National Institute for Standards and Technology (NIST) in Boulder, Colorado, in 2010.[(3)] They used two very accurate atomic clocks, they confirmed that the clocks were synchronous and ticking at exactly the same rate, and then they raised one of the clocks by just 33 centimeters (roughly 1 foot). As predicted by General Relativity, the raised clock ticked faster than the lower clock. The difference was in picoseconds (trillionths of a second), but more clearly than any other such demonstration, it showed that Time Dilation is **not** just an illusion. It is real, even if many physicists refuse to accept it.

The most compelling and undeniable demonstration of Gravitational Time Dilation happened more or less by accident. "International Atomic Time" or TAI (from the French name Temps Atomique International) involves keeping track of time data produced by 391 atomic clocks distributed all over the world in 69 different institutes (as of October 2010).[(4)] Most of the clocks are located at National Metrology (weights and measures) Institutes. In the 1970s, it became clear that all the clocks participating in TAI were ticking at slightly different rates, mostly due to gravitational Time Dilation. The NIST's clock in Boulder, Colorado, for example, was at least 5,430 feet above sea level, while an atomic clock at the National Physical Laboratory in Teddington, England, was likely less than 100 feet above sea level. Today's adjusted TAI scale, therefore, corresponds to an **average** time at mean sea level. Because the participating

clocks had been mostly located well above sea level, that meant that the official TAI second slowed down by about one part in a trillion, i.e., the official second became about one picosecond longer.

There have been many other demonstrations of Velocity Time Dilation and Gravitational Time Dilation, the best known being the Hafele-Keating experiment in 1971[(5)] which involved carrying atomic clocks aboard jet aircraft circling the globe with and against the Earth's rotation.

Inexplicably, that seems to be all that the demonstrators do: they confirm that Time Dilation is real, and then they step aside and just watch the reaction. They never address the very controversial ***implications*** of Time Dilation being a real natural phenomenon.

## Implication #1

The first implication resulting from viewing Time as it ticks at one rate at floor level and at a faster rate just a foot above floor level, is that Time is clearly not just a "concept" or "idea." Concepts and ideas do not slow down when they move about or get close to a gravitational body. The Time Dilation experiments indicate that Time is an ***effect*** resulting from some property of matter. When an object moves, time slows down for that object and **only** for that object. When an object gets closer to a gravitational mass, time slows down for that object and **only** for that object.

Time Dilation has also been repeatedly demonstrated with tiny atomic particles known as muons. In the muon experiments, it appears that the faster a muon moves, the longer that specific muon will exist, because Time slows down for that muon.[6]

The muon experiments also indicate that Time works at the subatomic level. The evidence clearly says that Time is **caused** by some property of the atoms and particles that comprise matter. Some of the more obvious effects caused by that property of matter are aging and decay. However, regular mechanical operations, cognitive functions and perception will evidently also slow when time slows. And there seems to be only one possible property that can cause all the various effects of Time Dilation: the mysterious property known as "particle spin." Here is how one source describes the discovery of "particle spin":

> Starting in the 1920s, Otto Stern and Walther Gerlach of the University of Hamburg in Germany conducted a series of important atomic beam experiments. Knowing that all moving charges produce magnetic fields, they proposed to measure the magnetic fields produced by the electrons orbiting nuclei in atoms. Much to their surprise, however, the two physicists found that electrons themselves act as if they are spinning very rapidly, producing tiny magnetic fields independent of those from their orbital motions. Soon the terminology 'spin' was used to describe this apparent rotation of subatomic particles.[7]

According to some experts, "The spin of an electron never changes."[8] But that appears to be much like the claim that the speed of light never changes. The experimental evidence seems to indicate that both change depending upon the object's speed and altitude.

When the NIST raised an atomic clock 1 foot and observed that it ran faster at that height than at the lower level, they were observing that the single aluminum ion (electrically charged atom) being used to measure time was vibrating faster between energy levels by a few quadrillionths of a second. A mechanical clock using gears and springs would also run faster at

the higher altitude, but without the capability of showing such a precise time difference per second. A person would age faster, a calculator would calculate faster, and an apple would decay faster, but they, too, would not be able to show the tiny changes in the rate that Time passes for them. The evidence says they all experience Time moving faster because the particles from which their atoms are constructed "spin" at a faster rate when farther from a gravitational mass.

Of course, it can be argued that "spin" is not Time, that it is just another way of **measuring** Time. But, we can measure Time ***because*** it exists. If we could not measure Time, it would be just a "concept." The Time Dilation experiments clearly indicate that the **effect** of Time running at different rates is **caused** by some physical property of matter. And, it appears that the only known property of matter that could be the **cause** of Time Dilation in all the experiments is particle spin. The implication is that Time is an **effect** of particle spin, and particle spin is the **cause** of Time.

Of course, if aging, decay, perception, cognition and other physical processes used to measure the passing of Time are caused by "particle spin," that also means that Time does not and cannot exist in a vacuum or in any empty space between objects. And therefore, "Space-time" becomes merely a flawed mathematical construct, an obsolete mathematical model that needs to be replaced by a new mathematical model that better fits reality.

## Implication #2

The second implication of Time Dilation is that Time passes at a different rate virtually everywhere. In his 1905 paper which introduced Special Relativity to the world, Einstein wrote this about variable time:

> "Thence we conclude that a balance-clock at the equator must go more slowly, by a very small amount, than a precisely similar clock situated at one of the poles under otherwise identical conditions."[1] (He was viewing the earth as being a perfect sphere, which it is **not**. But the concept is also true with a sphere somewhat flattened at the poles, even if it makes it difficult to separate calculations for velocity time dilation from gravitational time dilation.)

The fact that a clock ticks slower at the equator than an identical clock at one of the poles also means that a clock in Spain ticks slower than a clock in England, and a clock in England ticks slower than a clock in Finland. Coupled with the fact that clocks at different altitudes tick at different rates, that means **the length of a second is different virtually everywhere**.

The length of a second is officially defined as "the duration of 9,192,631,770 cycles of microwave light absorbed or emitted by the hyperfine transition of cesium-133 atoms in their ground state undisturbed by external fields."[9] In other words, a standard "second" is 9,192,631,770 "ticks" of a cesium based atomic clock. And, if you need to be more precise than that, you can measure fractions of a "tick." (Of course, the main reason for having a "standard" is so people can compare how their local time measurements **differ** from the "standard.")

But the length of a local second is different virtually everywhere. That means that, if the NIST laboratories in Boulder, Colorado (which is at least 5,430 feet above sea level) has an atomic clock that ticks at the rate of 9,192,631,770 ticks per **local** second, and an identical clock elsewhere on earth ***also*** ticks at 9,192,631,770 ticks per **local** second, any comparison of the two **local** tick rates will almost certainly show they merely **appear** to tick at the *same* rate because the lengths of the **local** seconds are ***different***.

## Implication #3

Implication #3 is that a key belief expressed by a great many mathematician-physicists is undeniably false. They believe and argue that Time Dilation is **reciprocal**, and they use an ***imaginary*** universe to argue their belief. Since everyone is moving and there is no stationary frame of reference in their imaginary universe (or in our real universe), mathematician-physicists argue that each observer can claim that his time is "normal" and time being experienced by another observer is running slow.[10][11][12][13]

However, in our real universe, Time Dilation is definitely **not** reciprocal. A scientist measuring time at the bottom of a mountain will see that his time is running **slower** than the time being measured by another scientist at the top of the mountain. The scientist at the top of the mountain will **agree**, since he can measure and see that his time is running **faster** than the time being measured by the scientist at the bottom of the mountain.

And, although it is more difficult to demonstrate with humans, velocity Time Dilation works the same way. The muon that travels at high speeds exists longer than a muon that is stationary or travels at slow speed. There is no reciprocal situation where any scientist can claim the long-lived muon actually traveled slow and existed for a short time while some other muon moved faster and existed longer. An astronaut twin who travels to some distant star and back at 95% of the speed of light will age 1 year while his twin on Earth ages 10 years. There is no reality where the twin on Earth actually traveled at 95% of the speed of light while leaving his astronaut twin sitting stationary at some point in space.

Time dilation is not reciprocal and no real experiment can show it to be reciprocal. Only mathematical models involving a fantasy universe will show time dilation to be reciprocal.

## Implication #4

Implication #4 may be the one that mathematician-physicists most want to ignore: the speed of light is **not** a constant. That fact also appears to be very easy to demonstrate via experiment, even though, inexplicably, it seems no one has publicly done so (while also realizing that is what they were doing).

It appears that speed of light will be 299,792,458 meters per second when emitted and measured at the level of the lab in Teddington, England; it will be 299,792,458 meters per second when emitted and measured at the NIST labs in more than "mile high" Boulder, Colorado; it will be 299,792,458 meters per second when emitted and measured aboard the International Space Station; and it will be 299,792,458 meters per second when emitted and measured virtually anywhere on Earth or in space. So, all observers at all those points will view the speed of locally emitted light as traveling at 299,792,458 meters per second. But, since ***the length of a second is different virtually everywhere***, in reality the speed of light is ***different*** virtually everywhere.

If the length of a second is different everywhere, which location and which clock provides the length of a second that is used to measure the so-called "fixed" speed of light?

In reality, the speed of light is only guaranteed to have a value of 299,792,458 meters per second in a vacuum when measured by someone situated next to the measuring equipment.[(14)] While astronomers in the distant past used various methods to get **approximations** of the speed of light coming from celestial objects, we have no tools to measure such incoming light with the same precision we measure the speed of light we create in a laboratory ourselves.

However, if the NIST can measure the difference in the rate of Time between a clock at floor level and another clock one foot higher, someone can surely measure and ***compare*** the difference in time atop a building versus on a lower floor of the same building. And they can also measure the speed of light **per second** at those two locations. We know from countless experiments where comparisons were not made what the results must be. (The Pound-Rebka experiment[15] achieved the expected results even though they assumed the measured changes in the wavelengths of light they observed were the result of the direction the light traveled (up and down vertically) instead of the difference in the speed of light as it was emitted at its source altitude.)

Any mathematical model which assumes a fixed speed of light is not representative of our existing universe and will almost certainly produce incorrect answers.

## II. CONCLUSION

It appears there is only one point in our entire universe where time and light move at their maximum rates: the hypothetical stationary point (outside of our visible universe) where the Big Bang occurred. All matter moved outward from that point, and, in theory, all matter is evenly distributed in all directions from that point, thus providing not only a stationary point, but the only point where the pull of gravity is the same from all directions.

In the rest of the universe, and particularly in the part of the universe that is visible to us, virtually all objects are moving, and thus Time for all objects will be dilated, i.e., slower than the maximum rate of Time. Until we can find a point in our universe that is stationary and where all

effects of gravity are in equal balance, we may have no way to precisely determine the actual difference between Earth Time and the maximum Time. We can only compare the dilated Time being experienced by one specific object to the dilated Time being experienced by another specific object.

The idea that the current mathematical model of the universe is no longer valid is not new.[16] Comparisons are made to Ptolemy's geocentric mathematical model of the universe, which was accepted as inviolate for over a thousand years. But as better instruments were developed and better measurements made, it eventually became clear that Ptolemy's model of an Earth centered universe was invalid and that a Sun-centered mathematical model more correctly fitted observations. That mathematical model held true until it was observed that the Sun traveled around the Milky Way galaxy. So it is with the current mathematical model for space-time. The model cannot handle time running at different rates for a single observer, as occurred in the NIST experiment, nor can it handle the idea that the speed of light is variable, as measurements of time and the speed of light at different altitudes indicate to be true.

The key points being made in this paper are

1) Science needs a new mathematical model based upon variable time and variable speed of light that fits better with reality than the current space-time model.

2) Time is a real, natural phenomenon that appears to be caused by a mysterious property of matter known as "particle spin."

3) Since it appears that "Unifying quantum mechanics and general relativity requires reconciling their absolute and relative notions of time,"[17] it is difficult to imagine anything more important to science than figuring out exactly how Time works.

## III. REFERENCES

(1) John Stachel, ed., Einstein's Miraculous Year: Five Papers That Changed the Face of Physics (Princeton University Press, 1998), pp. 123-160

(2) Dennis D. McCarthy and P. Kenneth Seidelmann, Time: From Earth Rotation to Atomic Physics (Wiley-VCH, 2009), p. 245

(3) James Chin-wen Chou, David B. Hume, Till Rosenband, David J. Wineland, - "Optical Clocks and Relativity," Science, 329, (2010) 1630-1633

(4) Dennis D. McCarthy and P. Kenneth Seidelmann, Time: From Earth Rotation to Atomic Physics (Wiley-VCH, 2009), pp. 189-222

(5) Joseph C. Hafele and Richard E. Keating, "Around-the-World Atomic Clocks," Science 177 (1972) pp. 166-170

(6) R. P. Durbin, H. H. Loar, and W. W. Havens, Jr., The Lifetimes of the π+ and π− Mesons, Physical Review 88 (Oct. 1952) p. 179

(7) Morton Tavel, Kurt T. Bachmann, What exactly is the 'spin' of subatomic particles such as electrons and protons? Scientific American (2017)

(8) ibid.

(9) Alessandro Ferrero, Dario Petri, Paolo Carbone, Marcantonio Catelani, eds., Modern Measurements: Fundamentals and Applications, (John Wiley & Sons, 2015), p. 55

(10) P. L. Sardesai, A Primer of Special Relativity, New Age International (P) Ltd. (2004), p. 21

(11) Leo Sartori, Understanding Relativity: a simplified approach to Einstein's theories, University of California Press (1996), p. 76

(12) Minoru Harada, The twin paradox repudiated, Physics Essays 24, 3 (2011), pp. 454-455

(13) Kexin Yao, Actual Time Dilation is Dependent on Absolute Velocity, Applied Physics Research; Vol. 7, No. 1 (2015), pp. 25-29

(14) Keith David Froome and L. Essen, Velocity of Light and Radio Waves, (Academic Press Inc., 1969)

(15) Robert Pound and Glen A. Rebka, Apparent Weight of Photons, Physical Review Letters 4, 7 (April 1, 1960), pp. 337-341

(16) Chandrasekhar Roychoudhuri, Causal Physics: Photons by Non-Interactions of Waves, Chapter 12, (CRC Press, 2014)

(17) N. Wolchover, Quantum Gravity’s Time Problem, Quanta Magazine (Dec. 1, 2016)