What is Time?

(It is Particle Spin.)

Edward G. Lake

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www.ed-lake.com

Abstract: *Albert Einstein's explanation of Time Dilation [1], along with "The Twin Paradox" explained by Paul Langevin [2], pose two scientific questions: (1) "What IS Time if it can be dilated?" and (2) "HOW is Time dilated by velocity and gravity?" The answers in this paper may be only a revisualization of what has been known for over a century, but it appears the topic has never before been explained by a layman in layman's terms. This paper is an expansion of an observation about Time Dilation described in my previous paper: "Time Dilation Re-Visualized.[3]"*

We call the period of time it takes for the Earth to make one complete orbit around the Sun to be "one year." But a "year" is not time. A "year" is a *measurement* of time. On Mars, a "year" is nearly twice as long as a year on Earth.

What we commonly measure and call "Time" is just an agreed-upon standard. Two centuries ago, "noon" occurred at a different time in nearly every town and city. Clocks were set to 12:00 "noon" when the sun was at its highest point during the day. Then the need for railroad schedules gradually created a requirement that everyone must use an agreed-upon standard for when "noon" occurred in a specific "time zone."

In his 1905 paper, Albert Einstein viewed time in a very different way. He explained that Time will run slower for an object whenever the object *moves*. For convenience, he used clocks to describe how movement (velocity) dilates (slows down) Time:

> If at the points A and B of K there are stationary clocks which, viewed in the stationary system, are synchronous; and if the clock at A is moved with the velocity v along the line AB to B, then on its arrival at B the two clocks no longer synchronize, but the clock moved from A to B lags behind the other which has remained at B by $\frac{1}{2}tv^2/c^2$ (up to magnitudes of fourth and higher order), t being the time occupied in the journey from A to B.

It is at once apparent that this result still holds good if the clock moves from A to B in any polygonal line, and also when the points A and B coincide.

If we assume that the result proved for a polygonal line is also valid for a continuously curved line, we arrive at this result: If one of two synchronous clocks at A is moved in a closed curve with constant velocity until it returns to A, the journey lasting *t* seconds, then by the clock which has remained at rest the travelled clock on its arrival at A will be $\frac{1}{2}tv^2/c^2$ second slow. 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.

The last sentence above explains that a clock at the equator will run slower than a clock at the North Pole simply because the clock at the equator is moving at about 1,000 miles per hour around the Earth's axis while a clock at the North Pole just rotates in place once per 24 hours. *Everything* at the equator that measures Time will run more slowly than an identical object at the North Pole. A human being standing on the equator will *age* more slowly (by a very small amount) than a human being standing at the North Pole.

This means that Time can (and does) "move" at a different rate for each of us. The rate with which Time "moves" depends upon your velocity and your distance from a large gravitational mass. The closer you are to the center of a large gravitational mass – such as the Earth – the slower time will move. That means that, because the Earth is not a perfect sphere but is slightly flattened at the poles, a clock at the North Pole is also 13 miles closer to the center of the Earth than a clock at the equator. The clock at the North Pole will thus run slower by a very slight amount, an amount which must be added to any amount of slowing caused by velocity.

That is one reason why, to simplify matters, this paper will first focus on Time Dilation caused by velocity. Gravitational Time Dilation will be discussed later.

Computations of Time Dilation are complicated by the fact that the person at the equator *and* the person at the North Pole are *both* moving along with the Earth at 66,000 mph (29.5 kilometers per second) as the Earth orbits the Sun, and *both* are moving with the Sun as it orbits around the galaxy at 483,000 mph (216.9 kilometers per second). [4] A total velocity of 300 kilometers per second only results in a difference of about ½ of a millionth of a second between the two people on Earth and a theoretical *stationary* object in “absolute space.” That’s roughly 36 seconds per year.

Time Dilation does not become noticeable until you reach velocities nearing the speed of light. If you move at a relative velocity of 298,290 kilometers per second (which is 99.4988% of the speed of light), you will experience only 1 second while a stationary person experiences 10 seconds. You will age “1 year” while a stationary person ages 10 years. Your clocks will tick off 1 year while a stationary clock will tick off 10 years.

The question then becomes: Exactly what are we measuring if Time will move at a different rate for someone on the equator versus someone at the North Pole?

It isn’t *just* velocity. A stationary person sitting motionless in “absolute space” will age normally, and his wristwatch will tick off the seconds normally.

But, as soon as he starts to move, Time for him and his clocks will start to slow down in comparison to what was occurring when he was sitting motionless.

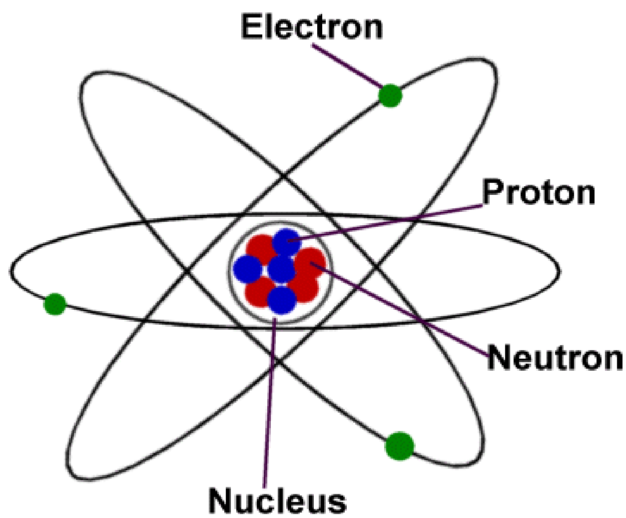
Since we are all moving, being “stationary” in “absolute space” is basically just a hypothetical concept. But the speed of light is NOT hypothetical. That is one reason why Time Dilation is typically computed by measuring an object’s velocity relative to the speed of light instead of relative to a purely hypothetical stationary object.

The speed of light is not only fixed, it cannot be exceeded by anything yet known to man. And since nothing can move faster than the speed of light, that means that Time Dilation ***must*** be caused by a some kind of “conflict” with the speed of light – a circumstance where whatever it is that controls Time is forced to slow down in some way because it cannot exceed the speed of light.

It appears there is only one “thing” that can cause Time to slow down when it bumps up against the speed of light – particle spin. And that observation seems to indicate that particle spin IS Time, and Time IS particle spin.

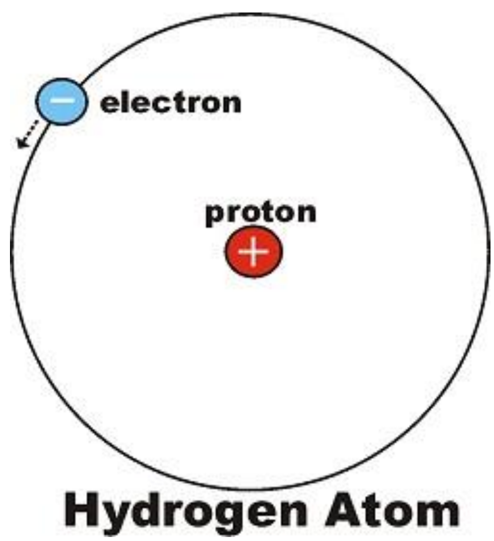
Since no one knows exactly what an electron looks like, nor exactly how “particle spin” works, it is easier to illustrate and explain how particle spin causes or controls Time Dilation if we use a more familiar model of an atom and its electrons.

Below is a model of an atom showing how electrons orbit around the protons and neutrons that form the atom’s nucleus.

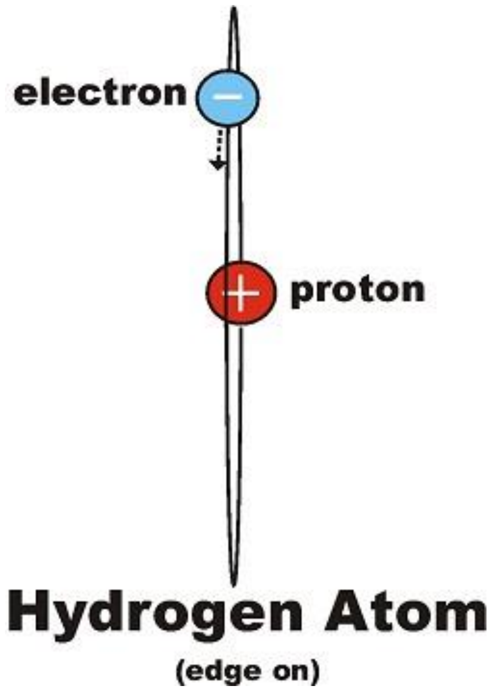


Each electron moves at a "fixed" speed in its orbit around the nucleus. It is a fixed speed the same way the speed of light is fixed. It cannot move faster (without changing orbits). And the electron itself is spinning (as are the neutrons and protons), much like the way the Earth spins on its axis as it orbits around the spinning Sun. Since neutrons, protons and electrons are particles, “electron spin” is the same as “particle spin.”

The simplest atom is the hydrogen atom, which consists of one electron orbiting a nucleus consisting of one proton. It can be visualized as looking like this:

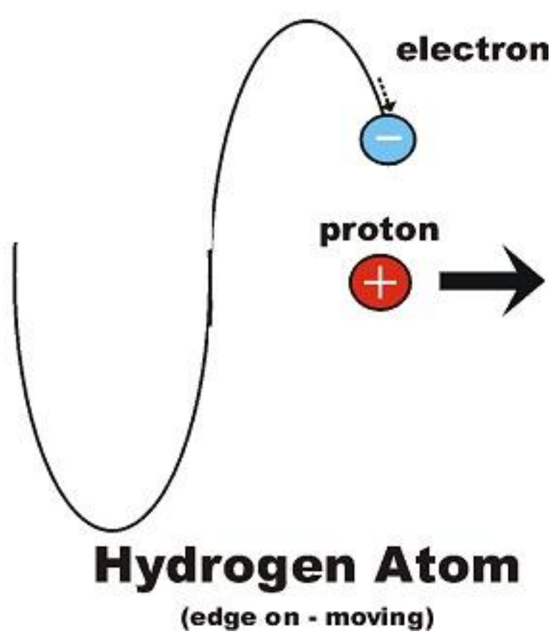


When viewed edge-on, the hydrogen atom would theoretically look like this:



Next we need to understand that although the speed (or velocity) at which the electron orbits the proton is fixed, the time it takes the electron to complete one orbit of the proton is NOT fixed. And therein lies the key to understanding the cause of Time Dilation.

Since we do not know exactly what an electron or proton looks like, it is easier to illustrate how a fixed velocity can result in an orbital period that is NOT fixed by continuing to use the hydrogen atom as our model. When the hydrogen atom is forced to move laterally through space, a circular orbit becomes a cork-screw path, and the distance the electron needs to move at its fixed velocity in order to complete one orbit increases proportional to the lateral speed.



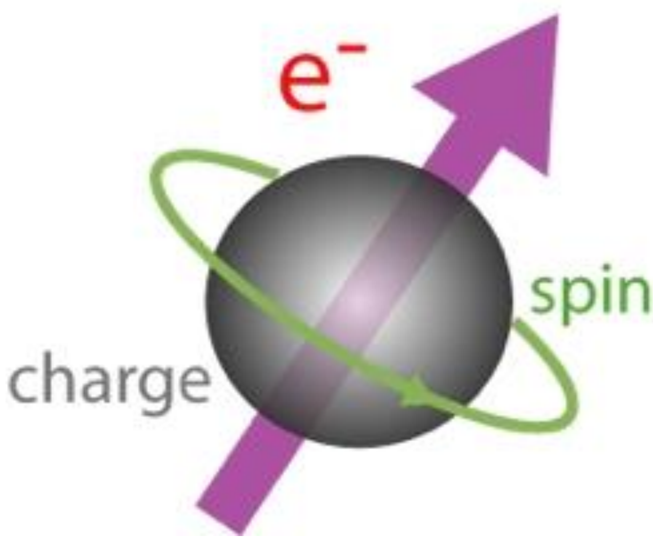
If we were to assume that one orbit by the electron around the proton *while the atom is stationary* equals “one fundamental unit of time,” we can then easily see how Time will dilate if the object containing the hydrogen atom is forced to move.

However, one “fundamental unit of time” is NOT one orbit of an electron around the proton of a stationary atom. Since any periodic process can be viewed as a “clock,” we must use the smallest or shortest *known* periodic process as the “fundamental unit of time.” And that is one “orbit” or “rotation” or “spin” of a stationary particle itself. We know this is necessary because we know Time Dilation also affects individual particles – muons being the primary example.

(Muons are unstable subatomic particles with a mean lifetime of 2.2 microseconds. They are created locally when cosmic rays collide with particles in Earth’s upper atmosphere. Their short mean lifetime does not provide enough time for the particle to reach the surface of the Earth, yet they *do* reach the surface in great numbers. That happens because their high speed (about 99 percent of the speed of light) slows down the Time they experience (i.e., they experience Time Dilation), allowing them to travel further before decaying.) [5]

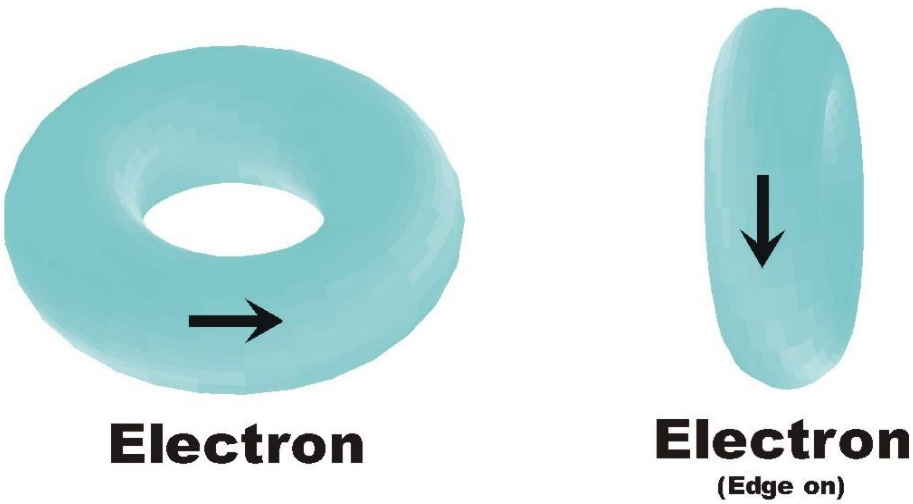
So, “a fundamental unit of time" is one complete spin of a hypothetical *stationary* particle. However, the Time we all experience is **NOT** fixed because particles do not remain stationary, and thus the time it takes for a particle to complete one spin is not fixed. One complete spin of a *moving* particle is one *dilated* unit of time.

Unfortunately, we do not know with any precision what a particle looks like or how it spins. Some theoretical models show an electron spinning just as the Earth spins on its axis:



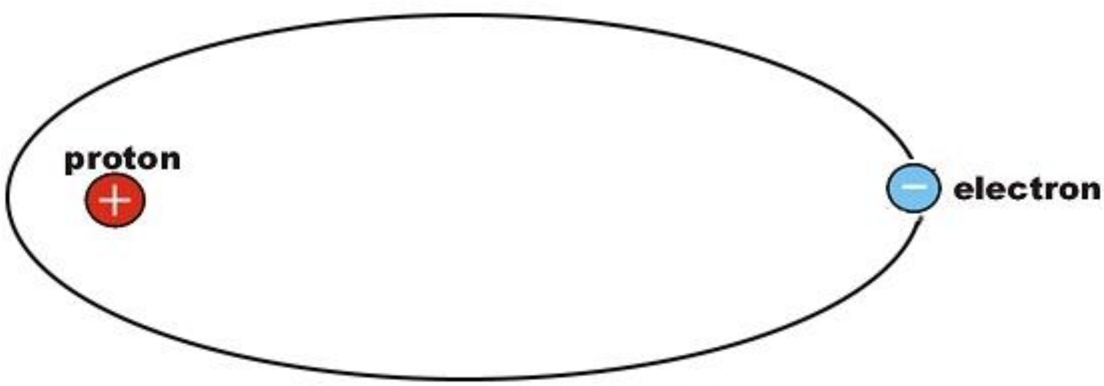
With such a model, in order to visualize how the moving electron tracks a parabolic path through space, you have to fix an imaginary point to the “surface” of the electron and follow the path that the point tracks.

A different and perhaps more accurate "model" turns the electron into a rotating "string," possibly looking very much like a donut.



I envision an electron as looking more like a dog chasing its tail, with a clear point to mark one complete rotation. However, it doesn't really matter what the electron looks like, just as long as it is understood that one orbit or rotation while stationary in space equals one "fundamental unit of time."

Which brings us to gravitational Time Dilation. Evidently, the shape of the orbit can also be elongated by putting the particle near a large object with significant gravitational pull. It is again more easily visualized with the hydrogen atom. Gravity's pull on the electron can elongate its orbit, turning it into a parabolic orbit. The electron still moves at its fixed speed, but it has to travel further to complete one orbit.



Electron orbit distorted by gravity

This way of viewing time also indicates that Time can ***stop***. When an object (such as an electron or a human) reaches the speed of light, the object ceases to exist as a coherent object and will become waves of energy moving across the universe forever. Time will stop for that object. Likewise, when an object enters a black hole, the electron will cease to spin and Time will stop.

This means that dilated Time is the *normal* form of Time. Everything in the universe is moving *and* is being affected by gravity. But the amount of Time Dilation is normally so small that we have all agreed to use a man-made "STANDARD" (such as the time measurement provided by the atomic clock at the National Institute for Standards and Technology) instead of trying to compute our own personal rate of time using the tiny clocks known as "particle spin."

What is Time? Time is the spin of sub-atomic particles. Time began shortly after the Big Bang, when particles such as electrons were formed, and Time will continue until electrons and other particles stop spinning.

It is tempting to relate Time to Entropy, since it appears that all the tiny "atomic clocks" in our bodies and in the materials around us were "wound up" and put into motion shortly after the Big Bang, and it appears they will run and keep their imperfect dilated time until the last two particles crash into each other and transform into photons which will just move through empty space forever. But that would be the subject of a different paper.

References

[1] Einstein, Albert (1905) – *On the Electrodynamics of Moving Bodies*. http://www.fourmilab.ch/etexts/einstein/specrel/www/

[2] Langevin, Paul (1911) – *L'Evolution de l'espace et du temps* http://arxiv.org/ftp/arxiv/papers/1205/1205.0922.pdf

[3] Lake, Edward G (2015) – *Time Dilation Re-Visualized* https://independent.academia.edu/EdLake1/Papers

[4] https://astrosociety.org/edu/publications/tnl/71/howfast.html

[5]

http://ph.qmul.ac.uk/sites/default/files/Engagement/Muons%20and%20Special%20Relativity.pdf