Relativity's Fundamental Ideas

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***Abstract**: Einstein's 1905 and 1915 papers on Relativity contain fundamental ideas that deserve individual study and understanding. Looking at them as specific "ideas," instead of as "principles" or "concepts," allows a clearer understanding of how they work together, separate from the many different ways they can be expressed mathematically.*

Key words: Relativity; time; time dilation; photons; motion; mass; gravity; acceleration.

The key fundamental ideas behind Relativity that will be discussed in this paper are:

1. Every atom is a tiny clock that creates time at its location.
2. Light is the transmission of energy in the form of photons from one atom to another.
3. Atoms emit photons at the speed of light, which is 299,792,458 meters **per second**.
4. A second **lengthens** when speed and/or gravity **increase** for the emitting atom.
5. A second **shortens** when speed and/or gravity **decrease** for the emitting atom.
6. Nothing can go faster than photons emitted from the slowest moving atom.

Fundamental Idea #1

Idea #1 says that Time is a function of atoms and particles. Einstein's 1905 paper "*On the Electrodynamics of Moving Bodies*"[1] describes Time as being a property of electrons. Time "ticks" in the form of oscillations of the electron's electric and magnetic fields. Einstein also wrote: “the velocity of the electron can be directly measured, e.g. by means of rapidly oscillating electric and magnetic fields.” That means that time will slow down if the electron is moving, and you can tell how fast the electron is moving relative to some other electron by measuring their oscillations rates. The faster moving electron will oscillate slower. Faster relative to what? Faster relative to the slower moving electron, of course, but also faster relative to the fastest speed allowed in our universe, the speed of light. Each electron is, in effect, a tiny clock that creates Time at its own location. And because other particles also oscillate at specific rates, each atom is, in effect, a tiny clock constructed of smaller clocks.

When you view every atom as a tiny clock, all you need is a *duration* measurement to complete our view of Time. We probably first began measuring duration time using orbits of the sun. From one dawn to the next dawn is a duration we measure as a “day.” Later, when we needed to be more precise because dawn to dawn is not a constant period of time, we measured a day from noon until noon. Then we used the periods of the moon to measure a larger group of days, which we call “months.” And approximately 12 months equals one “year,” or one change of seasons from winter to winter. Then, sundials were invented (or discovered), and we developed the idea of dividing a “day” into 24 “hours.” Then the need to divide hours into smaller increments caused humans to construct mechanical clocks which would measure 60 “minutes” per hour because 60 can be divided in half, in thirds, in fourths, in fifths and in sixths without getting into fractions. Then, when greater precision in measuring time was needed, we created “seconds.”

The Persian scholar Al-Biruni first used the term "second" around 1000. He defined it—as well as the day, hour, and minute—as fractions according to the lunar cycle. The first mechanical clocks to mark the second appeared in the 1500s, and in 1644 French mathematician Marin Mersenne used a pendulum to define the second for the first time, leading to the international adoption of grandfather clocks by the end of the 17th century. In the 19th century, scientific institutions worked to define the second in astronomical terms, and in the 1940s an international agreement defined the second as 1⁄86,400 of a mean solar day.[2]

Today, a second is officially defined as “being equal to the time duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the fundamental unperturbed ground-state of the caesium-133 atom.”[3] In other words, today we use the functions of atoms to precisely measure Time. And we now have Optical Lattice Clocks, which are much more precise than clocks which use the caesium-133 atom. An Optical Lattice Clock “ticks” 429,288,004,229,873.2 times per second, versus “only” 9,192,631,770 “ticks” per second for a cesium-based clock.[4]

When we humans look at Time, we tend to think of it in terms of recorded memories and projections for the future. Memories and measurements of Time are not Time itself. The “fundamental idea” here is that Time is a physical atomic and sub-atomic “process,” not a measurement or memory, nor just a concept or illusion. And because Time is a physical process which causes aging and decay, that process can be slowed by motion and gravity.

Fundamental Idea #2

Idea #2 is the realization that light is the transmission of energy in the form of photons from one atom to another. Light consists of photons with oscillating electric and magnetic fields, <u>not waves</u>. When a light bulb is turned on, electric energy is added to tungsten atoms in the thin filaments within the bulb. A tungsten atom can only contain a fixed amount of energy in the form of 74 electrons orbiting a nucleus containing 74 protons and 74 neutrons. When additional energy is added to the tungsten atom, that added energy makes the atom unstable, and it quickly ejects the excess energy in the form of a photon oscillating in the visible light range.

That process of adding energy to an atom and having the atom reject the energy in the form of a photon is the basic idea behind atomic clocks. With an atomic clock, the emitted energy is then immediately sent back into the atom, which the atom then again ejects. When you do this with a Caesium-133 atom, you add energy in the form of microwave photons to the atom, the atom immediately ejects that energy, you immediately add it back again, and you count the number of times this process can be done in one second. The official count is 9,192,631,770 times per second.

Of course, photon light from an ordinary light source is usually not immediately reflected back into the source. Instead, when emitted into a vacuum like empty space, the photon will just travel on until it hits some atom somewhere, which could be fairly close or billions of light years away. If it hits something reflective, it will be absorbed and then emitted as a <u>new</u> photon to continue its travels. If it hits something non-reflective, such as your eye, it will be absorbed and the energy will register in your brain as a brief spot of light. If it hits your skin, the energy will be absorbed and register in your brain as a brief touch of warmth.

Fundamental Idea #3

Idea #3 is the fundamental idea that, when any atom ejects a photon, it ejects that photon at the <u>*local*</u> speed of light, which is 299,792,458 meters <u>*per local second*</u>. “Local” in this case means at the location of the atom ejecting the photon. 299,792,458 meters <u>*per local second*</u> is also the fastest that anything can travel in our universe.

This poses a fundamental problem: We know of nothing that is truly stationary in our universe. If you are performing a measurement of the speed of light in a laboratory on earth, that laboratory is moving around the center of the earth as the earth spins on its axis at about 1,040 per hour at the equator. In addition, the earth is traveling at about 67,000 miles per hour in an orbit around the sun, and the sun is traveling in an orbit around the center of the Milky Way Galaxy at about 486,000 miles per hour.

We also know from many experiments that the speed of the emitter does **not** add to the speed of light that is emitted, or as Einstein stated it as his Second Postulate:

> light is always propagated in empty space with a definite velocity *c* which is independent of the state of motion of the emitting body.

To put it another way, regardless of the speed or direction of movement of the *emitting body*, light will always be emitted in a vacuum at *c*, which is 299,792,458 meters *per second*.

This poses some questions: What about the receiver? At what speed will light be received by an approaching observer? The answer is complicated: light will be received at *c*, but because the observer is moving, it is c using a longer second.

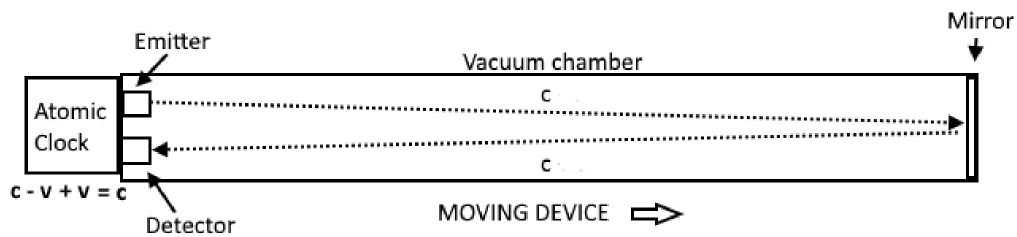

Figure 1

Figure 1 shows a typical device for measuring the two-way speed of light. If the device is stationary, light simply travels at *c* from the emitter to the mirror, and then at *c* from the mirror back to the detector. If the device is moving, the same thing happens, except for the fact that the length of a second is different. Either way, the device should provide a reading for the **two-way** speed of light as being 299,792,458 meters per local second.

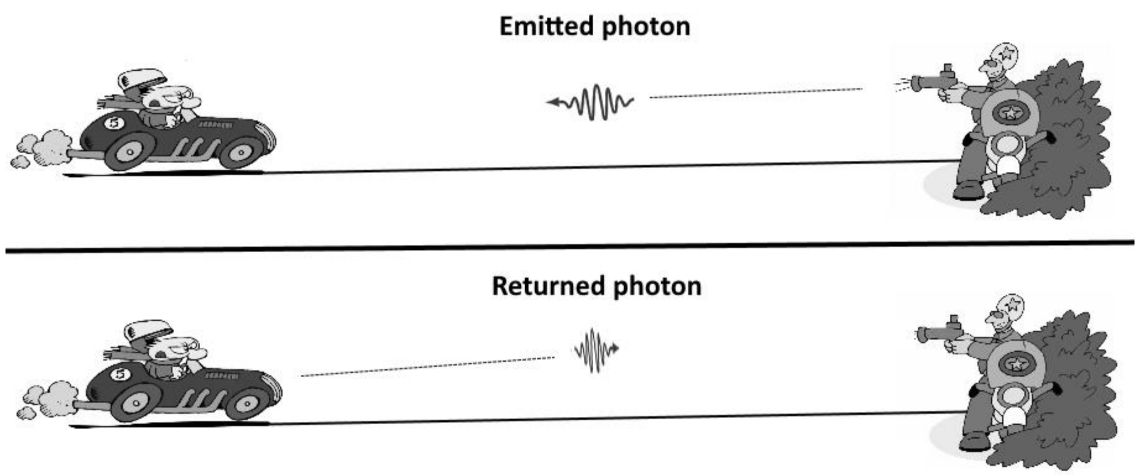

Figure 2

If you *assume* that light always travels at *c* or 299,792,458 meters per second (or 670,616,629 miles per hour), and if you know the oscillation frequency of the photons your device emits, you can then measure the speed of an "observer" by determining the difference in the light oscillation frequency between the emitter and receiver. This is the basic principle behind police radar guns, as shown in Figure 2 above.

In Figure 2, the police radar gun emits a photon that oscillates at 35 Gigahertz, which is 35,000,000,000 Hertz (Hz) or 35 billion times per second. That photon travels at *c* and hits an atom in some reflective surface on the approaching target at *c* where *c* involves <u>a longer second</u>. That atom absorbs the photon and, due to the target's movement, the atom <u>adds kinetic energy</u> to the photon that it immediately emits back toward the radar gun. It's often compared to the "Doppler Effect," although it is more accurately called "The Compton Effect," because the "Doppler Effect" applies to sound and results from motion by either the receiver <u>or the emitter</u>. The Compton Effect only applies to motion by the receiver.

Although the photon hits the target at *c*, the amount of energy added to the photon for its return trip is equal to the energy of a photon hitting at *c+v* or *c-v*, where *v* is the speed of the target. An atom in the mirror-like surface on the target absorbs the photon and then emits a <u>*new*</u> photon that oscillates at the *c+v* frequency as it travels at *c* back to the radar gun. The radar gun receives the new photon and compares it to the photons it emits and determines that the return photon oscillates at 35,000,001,792 Hz. The percentage that 35,000,001,792 Hz is of 35,000,000,000 Hz is exactly 2 times the percentage that 70 miles per hour is of 670,616,629 miles per hour, the speed of light. (More than one photon is emitted by a radar gun, of course, but the other photons simply verify what is measured by one photon.)

The key point: radar guns measure the speed of a target by measuring the speed of that target <u>**relative to the speed of light**</u>, not relative to the gun. Basic radar guns must be used while the gun is stationary in order to produce a valid reading. When a radar gun is moving, the returning photon will experience the Compton Effect when it hits the moving gun. That complicates the process and requires additional processing and an additional patent, but the gun is still measuring speeds relative to the speed of light.

Fundamental Ideas #4 and #5

Fundamental Ideas #4 and #5 are: (#4) a second <u>*lengthens*</u> when speed and/or gravity *increase* for the emitting atom, and (#5) a second <u>*shortens*</u> when speed and/or gravity *decrease* for the emitting atom.

In other words, the faster an atom moves, the slower that atom's components oscillate or spin, and the longer a second is for that atom. The clock that is an atom runs slower when that atom moves faster through space or when it gets closer to a gravitational mass. Today we call this "Time Dilation."

That means that, as many experiments have shown, a clock ticks slower when it is being transported from place to place and when it is at a lower altitude and closer to the center of the earth. Only atomic clocks are able to measure such small changes in the length of a second, and atomic clocks can do it because they use atoms and photon exchange rates as their means of measuring time. They can divide a second into 429,288,004,229,873.2 “ticks,” and associated equipment can determine if another identical clock ticks at a different rate.

There is one more effect of Time Dilation that is almost never discussed. Because each atom is a tiny clock that ticks at its own rate, which is determined by how fast the atom is moving and at what altitude, and because atoms emit light at 299,792,458 meters *per local second*, that means that **most atoms emit light that travels at a different speed than light emitted by other atoms**. The difference in speed is typically very tiny, of course, and since we know of no true way to measure the one-way speed of light, it can be difficult to argue against someone who claims that the speed of light is “constant” throughout the universe. The speed of light is always *emitted* at 299,792,458 meters *per second* everywhere, but because the length of a second can vary almost everywhere, the speed of light per second can actually be different almost everywhere.

And that brings us to

Fundamental Idea #6

Idea #6 is that nothing can go faster than photons emitted from the slowest moving atom. This idea is commonly stated as “Nothing can go faster than the speed of light.” That idea is basically true, but if light travels at different speeds, as ideas #4 and #5 say it does, then light from a slow-moving emitter can travel faster than light from a fast-moving emitter. And that means that the slower the emitter travels, the faster the light it emits will travel. Of course, that poses the question: An emitter moving slower relative to what? The answer: slower relative to all faster moving emitters. That may seem like double-talk, but what it means is that there must be some place in the universe that is either “stationary” or is moving slower than every other place in the universe. Logically, that location would be the location where the Big Bang began. Everything moved outward from there and began to spin, plus all mass in the universe should be evenly distributed in all directions from that location, meaning that the effects of gravity would be null at that point, just as gravity should measure as zero at the center of the earth.

Mathematically and logically, every point in space that is stationary relative to the point of the Big Bang can also be considered to be “stationary,” assuming it is not close to some gravitational mass. But, before you can find such a point, you need to find the point of the Big Bang.

Einstein addressed this issue in his paper "*The Principle Ideas of the Theory of Relativity*"[5] where he compared time as measured on the sun to time as measured on a "body" hurled from the sun at a speed of 1,000 kilometers per second (kps). To make things easier to understand and compute, Einstein rounded the speed of light to 300,000 kps. He then described how a "ray of light" emitted from the sun would travel 299,000 kps faster than the hurled body. It would hit the hurled body at 299,000 kps, as a second is measured on the sun, but at 300,000 kps as a second is measured on the hurled body. But what would happen if the emitted body were to emit light? Einstein states, "we know that the velocity of light does not depend upon the state of motion of the light source" and then he explains,

> The law of light propagation is the same, whether the sun or the projected body is chosen as the body of reference. The same ray of light travels at 300,000 kilometers per second relative to the sun and also relative to the body projected at 1,000 kilometers per second. If this appears impossible, the reason is that the hypothesis of the absolute character of time is false. **One second of time as judged from the sun is not equal to one second of time as seen from the projected body**.
>
> **There is no audible tick-tock everywhere in the world that could be considered as time. If physics wants to use time, it first has to define it.** In this endeavor it is apparent that this definition necessarily requires a body of reference, and that this definition makes sense only with respect to this chosen body of reference. **It turns out that one can define time relative to this body of reference such that the law of the propagation of light is obeyed relative to it. This definition of time can be realized for bodies of reference in any state of motion.**

In Einstein's convoluted way he is simply saying that an observer on the sun sees his light travel at 300,000 kilometers per second, and an observer on the emitted body also measures the speed of light he emits as 300,000 kilometers per second. However, because the emitted body is moving faster than the sun, a second is longer for the emitting body.

Conclusion

There are *other* fundamental ideas about Relativity, of course. The idea that mass can be converted to energy ($E=Mc^2$) may be the best known. The six fundamental ideas I chose to discuss were chosen primarily because they address a total disagreement between Relativity and Quantum Mechanics on the issue of <u>Time Dilation</u>, and many well-known experiments clearly show that Quantum Mechanics is wrong on that issue.

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