Course Project - Einstein's Physics Compare and Contrast

Shaun Pritchard

Rasmussen College

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Arunava Roy

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Einstein's theory says that time and space are linked together. Einstein also said our universe has a speed limit known as the speed of light. Nothing can travel faster than the speed of light (186,000 miles per second). The faster you travel, the slower you experience time known as Time-dilation *(Sceintific America, 2014)*.

Physicists have verified Albert Einstein’s prediction of the special theory of relativity through experimentation. Experiments such as particle accelerator in Germany confirm that time moves slower for a moving clock than for a stationary one. There have been experiments that show when 2 airplanes one traveling faster with the other one with set clocks show time moves faster.

The first experiment to have observed was conducted by Ives and Stilwell in 1938 using the Doppler effect. The Ives–Stilwell experiment tested the contribution of relativistic time dilation to the Doppler shift of light. The result agreed with the formula for the transverse Doppler effect and was the first direct, quantitative confirmation of the time dilation factor *(Saathoff, 2011).*

The Doppler effect (or the Doppler shift) is the change in frequency of a wave concerning an observer who is moving relative to the wave source. It is named after the Austrian physicist Christian Doppler *(ScienceDirect, 1982).*

More recent studies and publication show test of time dilation in special relativity has been performed using laser spectroscopy on fast ions at the heavy-ion storage-ring TSR in Heidelberg. he Doppler-shifted frequencies of a two-level transition in 7

Li+ ions at v = 0.064c which have been measured in the forward and backward direction to an accuracy of Δν/ν=1×10^−9 using collinear saturation spectroscopy. The result confirms the relativistic Doppler formula and sets a new limit of 2.2 × 10^-7 for deviations from the time dilation factor *(Botermann, 2014)*.

Mandy, therefore, had an understanding of Einstein's principles she knew she was a little younger because the time for her traveling several hundred miles per hour on an airplane where relevant to the time of someone standing still on earth particularly back her friends in New York in which time was running more normally.

If we know that the earth rotates once every 23 hours, 56 minutes, and 4.09053 seconds, called the sidereal period, and its circumference is roughly 40,075 kilometers. Thus, the surface of the earth at the equator moves at a speed of 460 meters per second--or roughly 1,000 miles per hour.

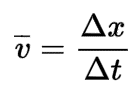
We can equate this to the average time humans on earth are traveling at a constant rate. Therefore, since we are all traveling on this planet are velocity is the same and the speed, we travel is equal to 0. Just like the example of riding in the car and trying to measure the driver while sitting next to them.

**Velocity:**

*v = average velocity*

*Δx = displacement*

*Δt* = change in time



**GPS In Relation to Time Dilation Special Relativity**:

GPS also harnesses the concept of special relativity. GPS accounts for relativity by digital and computationally adjusting the rates of the satellite clocks in orbit, and by building mathematical corrections into the computer chips which solve for the user's location on earth. Without the proper application of relativity, GPS would fail without using these principles *(NASA, 2020).*

GPS satellites orbit around Earth very quickly at about 8,700 miles (14,000 kilometers) per hour. This slows down GPS satellite clocks by a small fraction of a second. We also have satellites that are also orbiting Earth about 12,550 miles (20,200 km) above the surface. This speeds up GPS satellite clocks by a slighter larger fraction of a second. : Einstein's theory also says that gravity curves space and time, causing the passage of time to slow down. High up where the satellite's orbit, Earth's gravity is much weaker. This causes the clocks on GPS satellites to run faster than clocks on the ground. The combined result is that the clocks on GPS satellites experience time at a rate slightly faster than 1 second per second. hence, why we can use mathematics to calculate and correct these differences in time for satellites relative to our positions here on earth.

**Personal Experience with Special Relativity:**

In my personal experience, I grew up in the '80s where we had big giant clunkers called television with knobs we had to manually pull on with no remotes. These sets used a technology called (CTR) Cathode Ray Tubes *(Oxford, 2020).* Which essentially were vacuum tubes that shoot beams of electrons guided by magnets to phosphorus surfaces that reacted with the particles making them glow. Creating lights in the form of pixels that formed television pictures. Everyone had a powerful physics kit in their living rooms. I still have that I play with.

cathode-ray tube, electrons are ejected from the cathode and accelerated through a voltage, gaining some 600 km/s for every volt they are accelerated through. Some of these fast-moving electrons crash into the gas inside the tube, causing it to glow, which allows us to see the path of the beam. Helmholtz coils can then be used to apply a quantifiable magnetic field by passing a known current through them. A magnetic field will cause a force to act on the electrons which are perpendicular to both their direction of travel and the magnetic field. This causes a charged particle in a magnetic field to follow a circular path. The faster the motion of the particle, the larger the circle traced out for a given field or, conversely, the larger the field needed for a given radius of curvature of the beam *(Doherty, 2004).*.

The electrons in a cathode ray tube television travel from the electron gun to the screen at a speed that is about 1/3 the speed of light. The time measured by a stationary clock is important to relativity known as proper time, t0. This is the time measured by an internal clock on the electron. To this clock, the electron is at rest, and the television is moving past at 1/3 the speed of light. We can see the principles of special-relativity time dilation being applied to these devices to calculate the shoots of electrons passing through these magnetic fields to make sure they appeared on the screen in sequence to the broadcast media data transmitted to the televisions. Without the calculations and mathematics founded by special relativity for time dilation, the television broadcast would be very blurry and unnoticeable to view *(Doherty, 2004).*

These same principles are also applied it television remotes, radar systems, and many other modern devices. Infrared remotes use time dilation calculations to sequence code transmissions sent to the receiver to tell it to perform a specific action like turning the channel *(Oxford, 2020).*

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