



Research Paper

Theory of Relativity – Explained Simply (and with a Twist)

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ABSTRACT

Ever want to know why time seems to creep along in math class but zooms during lunch? Well, it turns out that time actually can change—though not because teachers are boring.

The Theory of Relativity is one of the most groundbreaking and interesting concepts in modern physics, introduced by none other than the genius who had more than 160+ IQ - Albert Einstein. At first glance, relativity may sound confusing, overly complex, and reserved for scientists with PhDs and chalk-stained lab coats who write 20 variable-based equations, but the truth is, relativity shapes our everyday lives more than most people realize. From GPS (Global Positioning Systems) on our phones to the very way we understand space and time, Einstein's ideas remain central to science today.

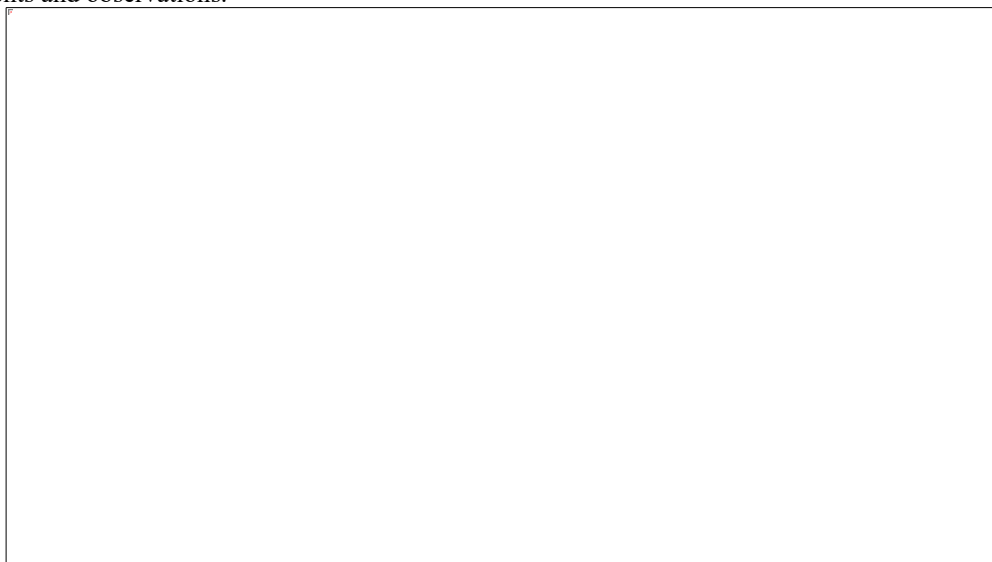
This paper, written by me, Advay Bajaj, a student of Grade 9 in one of the best schools in the United Arab Emirates (UAE) Mayoor Private School, explores relativity in a simple, engaging way, highlighting its two major parts—**Special and General Relativity**—While also diving into famous thought experiments, such as the Twin Paradox, and real-world evidence proving Einstein's theory correct. This paper will take you through the twists and turns Einstein went through to produce the key to the success of future Physicists and ones who love to explore the world of physics (Like myself).

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I. INTRODUCTION

Albert Einstein's Theory of Relativity transformed the world's understanding of physics, time, and gravity. One of Albert's greatest discoveries was that space and time are connected in a sort of **graph like manner**. It is known as '**Space-Time**'. General Relativity (1915) built on this, redefining gravity as the curvature of spacetime caused by massive objects. The theory predicted phenomena like time dilation, gravitational lensing, black holes, and gravitational waves—all of which have been confirmed through experiments and observations.



One important fact to highlight is how hard it was to prove Albert Einstein's theories correct. Albert Einstein's General Relativity had a mathematical flaw present in it. It was known as the Schwarzschild's singularity. The Schwarzschild singularity is basically the "uh-oh spot" in Einstein's equations. When Karl Schwarzschild solved Einstein's math for what happens around a super-massive object, he found that at a certain point, the math just blows up into infinity. That point is what we now call a black hole's center (the singularity).

In easy words: imagine squeezing all of Earth into a ball the size of a peanut. Now imagine squeezing it even more until all its mass is packed into a single point with no size at all. That's a singularity — a place where gravity is so strong that space and time completely break down, and the normal laws of physics just stop working.

Because of this flaw, many people stopped believing in the theories of Einstein, until proven. Recently, after the death of Albert Einstein, a Neutron Star was discovered, proving that the singularity **DID ACTUALLY EXIST** and this further went on to prove black holes also exist.

This paper outlines the origins of relativity, its key principles, experimental evidence, and its lasting impact on science and technology. Special Relativity (1905) showed that time and space are connected, not absolute, and introduced the famous equation $E = mc^2$, proving mass and energy are interchangeable.

III. MAIN

3.1 ORIGINS OF SPECIAL RELATIVITY

Einstein developed Special Relativity in 1905, inspired by everyday observations such as the synchronization of clocks on railroads. **YES, HE ACTUALLY GOT THE IDEA OF SPECIAL RELATIVITY FROM TRAINS, RAILROADS AND CLOCKS ON RAILROADS.** He proposed that space and time are not fixed but instead woven together in a four-dimensional fabric known as **spacetime**. A groundbreaking idea was encapsulated in $E = mc^2$, showing that mass and energy are two sides of the same coin—a concept with enormous implications for astrophysics and nuclear science.

One more shocking consequence is **time dilation**: moving close to the speed of light slows down time. If someone travelled on a spaceship near light-speed, they would age slower compared to people on Earth, which brings us to our next point.

3.2 THE TWIN EXPERIMENT (PARADOX)

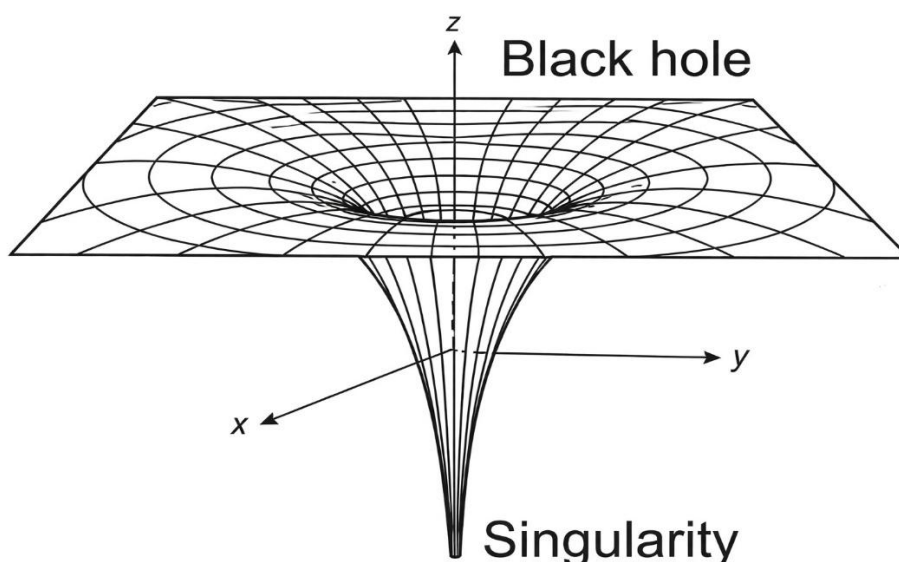
One of the most famous illustrations of Special Relativity is the **Twin Experiment**. Take two twins, just out of the womb and a few seconds into life. If I put one twin into a rocket-ship that travels at near-light speed while the other stays and lives a normal life on our breathtaking planet Earth, we would see that the twin returning from space would be way younger than the twin who stayed at earth. This thought experiment demonstrates that time is relative, not universal. Real-world tests with atomic clocks on satellites and planes confirm this effect, and GPS satellites must adjust for it daily to remain accurate. Without relativity, your phone wouldn't even find the nearest pizza place correctly.



3.3 GENERAL RELATIVITY AND GRAVITY REDEFINED

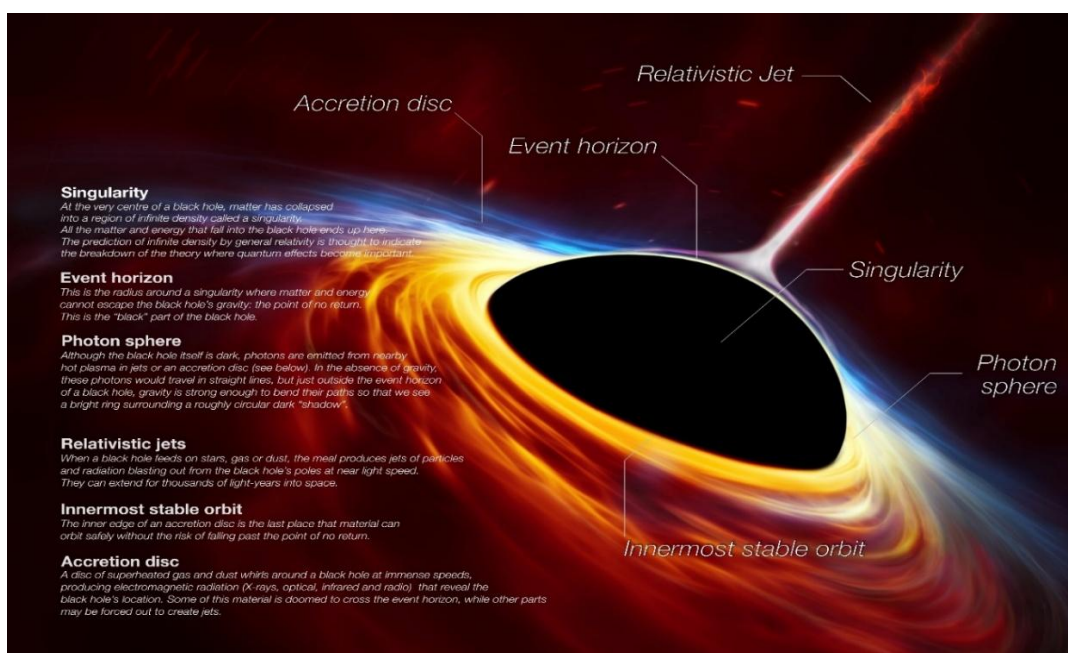
In 1915, Einstein expanded his ideas into General Relativity, tackling gravity itself. Instead of seeing gravity as a pulling force, Einstein described it as the bending of spacetime around massive objects like stars and planets. This means Earth orbits the Sun not because it is "pulled," but because the Sun warps spacetime around it. We could further describe this phenomenon by an experiment. Take a heavy ball and place it in the middle of a

trampoline. Next, use a marble, and roll it around the ball. This perfectly imitates the movement of the Earth around the Sun. This theory predicted phenomena such as light bending around stars (gravitational lensing), time slowing down near massive bodies, and the existence of **black holes**.



3.4 CHALLENGES AND PROOFS

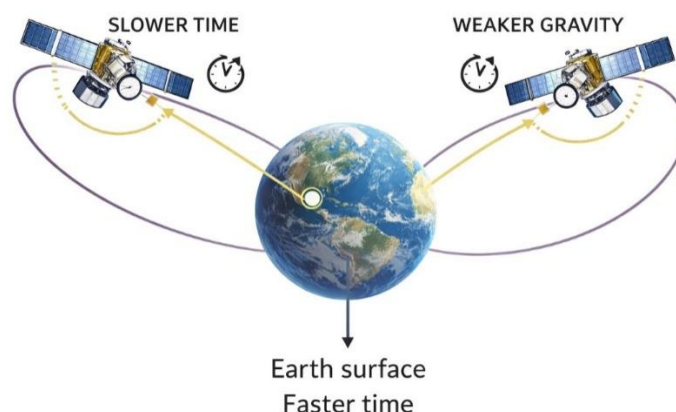
Einstein's equations revealed a mathematical puzzle called the **Schwarzschild Singularity**, leading to scepticism about the theory's accuracy. However, discoveries in the 20th century, such as the detection of neutron stars (1967) and black holes, confirmed relativity's predictions. More recently, the **LIGO experiment (2015) detected gravitational waves ripples in spacetime caused by colliding black holes**—providing direct proof that Einstein's century-old ideas were correct.



3.5 EVERYDAY APPLICATIONS

Though relativity sounds abstract, it is vital for modern technology. **GPS systems rely on relativity corrections**, satellites account for time dilation, and even astrophysical discoveries such as black holes and neutron stars are based on relativity. From helping us understand the universe to guiding us to coffee shops, relativity is everywhere.

THEORY OF RELATIVITY AND GPS



IV. CONCLUSION

So now you know that time isn't same everywhere. Let's take an example, shall we? We take a table and a pencil, and we leave it in the enormous fabric of Space-Time. What do you think will happen?

Imagine spacetime as a giant stretchy trampoline. If you put a table on it, the table has mass, so it will push down on the trampoline a tiny bit, making a very shallow dent. Then, if you put a pencil on the trampoline, it also makes a dent — but much smaller, because the pencil's mass is tiny compared to the table.

Now, what happens?

- If they're far apart, their little dents don't really affect each other. They just sit there.
- If you roll the pencil near the table, the pencil might "fall" slightly into the table's dent. This is exactly how gravity works: objects bend spacetime, and other objects move along those curves.

So, in short:

- Both the table and pencil bend spacetime a little.
- The table bends it more because it's heavier.
- The pencil could "feel" the table's curve and be attracted to it (just like how Earth "feels" the Sun's curve and stays in orbit).

In real life, though, the table and pencil's masses are way too small to make measurable spacetime dents. You'd need something enormous — like a planet, star, or black hole — for the bending to be noticeable.

Albert Einstein's Theory of Relativity completely reshaped how humanity sees the universe. Special Relativity connected time and space, while General Relativity redefined gravity as the warping of spacetime. Despite initial scepticism, relativity has been repeatedly confirmed by experiments and discoveries, from neutron stars to gravitational waves. It is not only a fundamental scientific theory but also a practical necessity for technologies like GPS. While relativity may seem confusing and counterintuitive, it stands as one of the most powerful and fascinating achievements in science, proving that even the strangest ideas can turn out to be true. So, the next time you use a 'simple tool' like a GPS, know that there is more physics than meets the eye.

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