Speeds of Light and Time with Gravity

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Abstract

This article discusses the variations of the speed of light through the fabric of space with and without the presence of the force of gravity. Also, since distance is calibrated by the speed of light, the force of gravity may also cause variations in distances measured.

Light waves travel though space at a speed of 299,792,458 m/s^2, no matter the speed or direction of the source. As light waves travel through outer space from distant galaxies on their way towards Earth they pass through the fabric of space with very little resistance. Where the universe is expanding the fabric of space has less resistance, allowing the true speed of the light wave to exceed the maximum speed limit. As the light waves approach a black hole, the fabric of space is displaced into a denser fabric with more resistance, forcing the light waves to slow down and take a detour around the black hole. The particles of light that make it around the black hole detour would once again be free to travel the maximum speed allowed by the fabric of space. All of this happens consistently in the fabric of space, but the constant speed of light may be better defined as the average speed of light, as the speed of light may be limited by the density of the fabric of space.

The speed of light is measured as distance (one meter) traveled over time (one second), and the distance of one meter is measured by the distance light travels in 1/299,792,458 of a second. Using this method of measurement limits the accuracy to local measurements. If the speed of light is restricted in any way by the force of gravity, then the measurement of the distance traveled would need to be calibrated for the change in distance traveled.

Gravity, or the lack of gravity may also change the measurement of the structure of the fabric of space. If the fabric of space is considered as an object with properties, like massless foam bubbles, then the bubbles would have distances between the center of each bubble. If atoms reside in the individual bubbles, then the distance between the center of the bubbles would change slightly as the force of gravity increased or decreased. The formation of the force of gravity may be the result of the increased displacement of the fabric of space as the mass of atoms and molecules accumulate into larger and larger objects. The mass of the object would be in direct correlation to the displaced fabric of space, or more specifically, the force of gravity.

Keywords

Light, Speed, Time, Gravity, Force, Fabric, Dilation, Space

1. Introduction

The fabric of space that all things in our known universe resides is difficult to define. Light waves traveling through space were explained by Einstein's theory of Special Relativity (1905) to have limiting properties like speed and direction [1]. Ten years later, Einstein published his theory of General Relativity, which included the very complex field equations explaining space and time [2]. The force of gravity that exists in the fabric of space was first discovered by Isaac Newton hundreds of years ago, but the true cause of the force of gravity has yet to be completely understood.

The speed of light is now defined by the Bureau of International Weights and Measures to be 299,792,458 meters per second, a meter is defined to be the distance light travels in 1/299,792,458 of a second, and time is measured by the actions of a Cesium atom [6]. These standards are established in laboratory conditions on the surface of the Earth, which will give consistent calibrations for everyone that is on Earth. Problems or inaccuracies may occur in calculations using those very precise measurements in different locations in the universe or even different altitudes on Earth.

Understanding the properties of the fabric of space can also lead to a better understanding of the four fundamental forces of nature. Gravitational, electromagnetic, strong, and weak forces may be related to the properties of the fabric of space. All the fundamental forces can be measured very accurately, but they may all be affected by the same thing, the displacement of the fabric of space by mass, creating a higher pressure or density of the fabric of space around the mass. If the size of an atom existing in the fabric of space is affected by the force of gravity, then the distance light travels to measure the size of the atom would also change. If the distance the light travels changes, then the time it takes to travel the distance also changes, creating an illusion of time dilation.

No two things can occupy the same space at the same time, including the fabric of space. Any object that has mass creates a sphere of higher pressure or density of the space surrounding the mass. The displacement of the fabric of space is the warping of space, explained by Einstein's theory of General Relativity, and is visually evident with the bending of light caused by gravitational lensing around black holes. The greater the mass, the greater the gravitational force pushing back on the mass from all directions. In areas of little or no mass, as found in deep space, the fabric of space is expanding. Specifically, the force of gravity is a direct result of the displacement of the fabric of space.

2. Gravity

Although gravity has been around since the beginning of time, Isaac Newton was the first to discover the force of gravity in the late 1600s. Isaac Newton's Philosophiae Naturalis Principia Mathematica (1687; The Mathematical Principles of Natural Philosophy) focused on force, mass, and motion, as well as introducing the universal force of gravity. In his definition of centripetal force Newton states "Of this sort is gravity, by which bodies tend to the center of the earth; magnetism, by which iron tends to the loadstone; and that force, whatever it is, by which the planets are perpetually drawn aside from the rectilinear motions, which otherwise they would pursue, and made to revolve in curvilinear orbits [3].” Newton explains the patterns of orbits caused by the force of gravity, but he did not know why mass caused the effects of the force of gravity.

The origins of the force of gravity were not understood in the 1600’s, as the idea that the earth was not the center of the universe was a relatively new idea. 200 years later, Einstein would expand on Newton’s laws of motion and the basic principles of modern physics that Newton developed.

Einstein explains gravity in his General Relativity theory as the warping of spacetime. He further describes the effects of the spacetime warping as a gravity well, where planets or moons continuously fall into orbits around other large masses [2]. Both Einstein and Newton focused on the effects of the force of gravity that was caused by the mass of the objects.

Since the mid-1900s, scientists around the world have been trying to identify and define the four fundamental forces in the Standard Model of particle physics at the European Council for Nuclear Research (CERN). There are four fundamental forces in the universe: the strong force, the weak force, the electromagnetic force, and the gravitational force. Gravity, the weakest of the four forces, thought by some scientist to be the elusive “graviton” particle, has not yet been found [4].

3. Fabric of Space Resistance

Einstein’s Special Relativity theory focuses on the speed of light, relative to the speed of everything else, consistently traveling no faster than the speed of light (299,792,458 m/s^2), no matter the speed or direction of the source of the light [1]. Many years later, Einstein’s theories of General Relativity accounts for large masses warping the fabric of space and time. These theories use the speed of light as the constant for speed and the measurement of time [2]. Using the speed of light as a constant, without factoring the effects of large masses warping the fabric of space creates a factor of time dilation.

In 1971, a time dilation experiment used airliners flying around the world in different directions equipped with multiple atomic clocks. The Hafele-Keating Experiment demonstrated that clocks tick faster at higher altitudes than a stationary clock on the surface of the Earth [5]. Now imagine time is the constant, and not the speed of light, then the distance light is traveling must be different to balance Einstein’s equations, as in Equation (1).

$$velocity = \frac{light\ path}{time\ interval}\ . \tag{1}$$

If the force of gravity creates a pressure force on an atomic level, and that force changes with distance from the mass causing the force, then the atomic size of the measurement may also change. If the velocity of light is measured by the light path per time interval, and the light path (distance) changes in different gravitational force conditions, then the speed of light would be reduced by that factor.

3.1. Measurement of a Meter Change

In 1983, an international commission on weights and measures set the speed of light to a precise whole number of 299,792,458, and to make everything consistent, changed the physical measurement of a meter from an actual metal bar in Paris to the distance covered by light in a vacuum in exactly 1/299,792,458 of a second [6]. Since these measurements do not factor the force of gravity, then changes noticed to the measurement of time away from the surface of the Earth may be a result of the change of the measurement of the distance traveled. What if the speed of light is directly correlated with the density of the fabric of space?

3.2. Displacement of Space-Time

General Relativity explains the warping of space around large masses and the forces of gravity [2]. What if the warping of space that Einstein is referring to is caused by the mass displacing the fabric of space, and that displacement is pushing back as the force called gravity? In other words, the warping of the fabric of space is the direct result of the displacement of the fabric of space, creating the force of gravity.

3.3. Fabric of Space Density

The displacement of the fabric of space could be described as a higher density, without mass, fabric of space, much like foam with very tiny bubbles. Imagine the individual bubbles of the foam on an atomic scale, where the size of a single bubble is the size of a Hydrogen atom. The bubbles would either be occupied with a single atom, with all the protons, neutrons and electrons, or empty space, not both. This force would be what binds all atomic particles together in their shells and this same force from the outside of the bubble would be the force of gravity acting on any mass.

Since there is very little mass in any single atom, or empty bubble, light particles pass through them like driving on an open highway. Measuring the speed of light in a vacuum, or the distance light travels in 1/299,792,458 of a second, would be like calibrating a speedometer on a highway using mile markers. Similarly, measuring the altitude or airspeed of an aircraft would need instrument calibration as the surrounding environment changed.

3.4. Speed of Light Origins

Centuries ago, in the year 1676, the finite speed of light was accidentally discovered by the Danish astronomer Ole Roemer, while gathering data on Jupiter's satellites discovered by Galileo in 1610 [7]. Roemer observed an 11 second time difference of the light from Jupiter's satellite when Earth was closest to Jupiter than when the Earth was farthest away six months later.

173 years after Roemer's observations of light speed in outer space, Hippolyte Fizeau conducted experiments on Earth using a pulsed light beam and a toothed wheel [8]. That was the first terrestrial measurement of the speed of light at 315,000 km/s^2, 5% high from the current 299,792,458 m/s^2.

Current methods of measuring the speed of light are like Fizeau's methods, but lasers and oscilloscopes replace the lanterns and cogged wheels. Mirrors are still needed, as the syncing of two clocks in different locations accurately may not be possible.

3.5. Fabric of Space Measurements

Continuing further with the analogy of light particles passing through the fabric of space like an open highway, imagine light particles passing through Empty Fabric of Space Foam Bubbles (EFSFB). The light particles have been measured to have a maximum speed of 299,792,458 m/s^2 [1]. These measurements have been taken in a vacuum on the surface of the Earth where the force of gravity is measured to be 9.8 meters per second. The distance the light travels in one second through the trillions of empty fabric of space foam bubbles would be "Meter Marker 1", instead of the familiar "Mile Marker 1" on the side of the highway. The density of the fabric of space, or gravity, would create a resistance to the maximum speed the light particles can travel, slowing the maximum speed of light.

The size of the EFSFB would also need to be considered. Measuring the number of individual bubbles that the light passes through, and the size of the individual bubbles would give the calibration measurement for the distance of 1 meter at a force of gravity on Earth of 9.8 meters per second. Since measuring empty space is extremely difficult at this time, measuring the probable size of a single Hydrogen atom in the same environment may give the same results.

4. Speeds of Light

Calibration of the distance measured is the key to discovering the speed of light in different conditions of empty space. If the diameter of an individual EFSFB is changed by the force of gravity or the speed of an object traveling through space, then time is the constant, not the speed of light.

4.1. Speeds of Light Measurements

Measuring the time differences of atomic clocks at different altitudes, and different directions flying around the Earth proved Einstein's theory that a clock at higher elevation will tick faster than a clock closer to Earth [5][2]. It does not prove that time itself is any different, at any time, or at any place.

4.2. Speed of Light Calibration

Predicting the effects of gravity on the speed of light can be done by subtracting the force of gravity metric from the light traveled distance over time, starting with Equation (2) for calculating speed, as in

$$R = \frac{D}{T} \ . \tag{2}$$

R – Rate of an object traveling a certain distance over time

D – Distance

T – Time

Applying Equation (3) factors in the force of gravity into Equation (2) by subtracting the gravitational force distance from the light traveled distance, as in

$$C = \frac{D_L - G_F}{T_S} \quad . \tag{3}$$

C – The rate of the speed of light (not as a constant), adjusted for the rate of the gravitational force.
D_L – The length of the path travelled by light in vacuum during a time interval of 1/299,792,458 second.
G_F – The rate of the force of gravity.

Equation (4) starts with the known speed of light on Earth at 299,792,458 m/s^2, which would be the adjusted speed of light in space at 299,792,467.8 m/s^2, less the gravitational force on earth of 9.8 m/s^2, as in

$$299{,}792{,}458 = \frac{299{,}792{,}467.8 - 9.8}{1} \quad . \tag{4}$$

Using Equation (3), the calculations for the speed of light in greater gravitational conditions eventually leads to the speed of light equal to zero. This is evident in the extreme gravitational condition near a Black Hole, as the force of gravity near a Black Hole is much greater than the speed of light.

Table 1 displays how the speed of light slows in relation to the increase of gravitational force, caused by the displacement or warping of the fabric of space-time.

Table 1. Speeds of Light at Gravitaional Conditions using Equation (3)

Location	Forces of Gravity to Speeds of Light		
	Force of Gravity (m/s^2)	Adjusted Speed of Light	Rate
Empty Space	0	299,792,467.8	m/s^2
Earth	9.8	299,792,458	m/s^2
Sun	274	299,792,193.8	m/s^2
Black Hole	> 299,792,467.8	0	m/s^2

Equation (4) also implies that the true speed of light in space would be 9.8 meters per second faster than any measurements taken on the surface of the earth, making the actual distances to neighboring stars just a little bit closer.

5. Speeds of Time

If the speed of light does not remain constant in all gravitational conditions, then the measurement of the distance travelled is no longer constant as well. Using the same gravity adjusted formula for measuring speed, Equation (3), the measurement of Distance Dilation (DD) becomes the variable, and time remains the constant.

5.1. Speeds of Time Calibration

If the speed of light in a vacuum, with zero gravity, is measured to be 299,792,467.8 m/s^2 and the speed of light on the surface of the Earth at 9.8 m/s gravity force, then the Time Dilation Calibration Factor (TDCF) would be 0.9999999673 seconds, as shown in Equations (3) and (5) as in

$$299{,}792{,}458 = \frac{299{,}792{,}467.8 - 0}{0.9999999673} . \tag{5}$$

Using Equation (3), the calculations for the TDCF in different gravitational conditions eventually leads to time equal to zero. This is also the theoretical case in the situation of a Black Hole, as the event horizon may be the point of no return, or where time may stop.

Time may not stop, but the measuring system may no longer be relative, as the measurement of a meter is collapsed to the atomic level, and simultaneously the speed of light reducing to zero, as in **Table 2**.

Table 2. Time Dilation Calibration Factor using Equation (3)

Location	Forces of Gravity Time Calibration		
	Force of Gravity	Time Calibration Factor	Time
Empty Space	0	1	Second
Earth	9.8	299,792,458	Second
Sun	274	299,792,193.8	Second
Black Hole	> 299,792,467.8	Null	

5.2. Universe Expansion

Equation (3) may also explain the expansion of the universe and light traveling faster than the speed of light. Negative Gravity (NG) conditions would exist as the forces of gravity shifts from the fabric of space pressure from every direction (zero gravity) to a condition of lesser pressure from any direction. The gravity force vector is still a positive number, but it would be pushing mass away from the denser fabric of space center of the universe.

The force of gravity as defined by Einstein is a directional force [2]. Imagine the known visible universe as an extremely large volume of the fabric of space. If the force of gravity around all planets, stars, black holes, and galaxies is the displacement of the fabric of space, then the outer portions of the universe would have less displacement and would be less dense, creating a condition of expanded or expanding fabric of space. This reduced density of space would allow for light to travel a greater distance in a fixed amount of time. Just like going from greater gravity to zero gravity.

Yes, in NG conditions light would travel faster than the speed of 299,792,458 m/s^2, which is the measured speed of light on Earth, although the measurement for a meter would also increase in less than zero gravity conditions, making the true speed of light a constant 299,792,458 m/s^2.

6. Conclusions

Large masses displace the fabric of space, creating a density of space. The density of the fabric of space is measured as the force of gravity. The speed of light is restricted by the density of the fabric of space. As the force of gravity increased, the speed of light decreases. The force of gravity may affect the speed of light, and the distance measured by the traveling of light. If the speed of light is used as a constant in all gravitational conditions, then the different conditions would need calibrations to correct the results.

By subtracting the force of gravity from the distance light travels in one second, as in Equation (3), the calibration for the speed of light in gravitational conditions is achieved.

Equation (3) also can be used to determine the amount the distance dilation occurs during a constant time of one second. If gravitational forces change the distance measured of mass and the fabric of space, then time is the constant, not the speed of light.

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References

[1] Einstein, A. (1905) 1. Definition of Simultaneity, 2. On the Relativity of Lengths and Times. *ON THE ELECTRODYNAMICS OF MOVING BODIES*, **3**, 4.

[2] MLA. Einstein, Albert, 1879-1955. The Collected Papers of Albert Einstein. Princeton, N.J.: Princeton University Press, 1987.

[3] Newton, Isaac (1687). Philosophiae Naturalis Principia Mathematica (The Mathematical Principles of Natural Philosophy).

[4] CERN (2022). The Standard Model. https://home.cern/science/physics/standard-model.

[5] Hafele, J. C.; Keating, R. E. (July 14, 1972. "Around -the-World Atomic Clocks: Predicted Relativistic Time Gains".

[6] Bureau of International Weights and Measures (1983). COMITE INTERNATIONAL DES POIDS ET MESURES - PROCES-VERMAUX. 72nd meeting. https://www.bipm.org/en/committees/ci/cipm/older-meeting-reports.

[7] American Museum of Natural History (2022). Ole Roemer and the Speed of Light. https://www.amnh.org/learn-teach/curriculum-collections/cosmic-horizons-book/ole-roemer-speed-of-light.

[8] H. Fizeau, Comp. Rend. Acad. Sci. (Paris) 29 (1849), 90-92.