Light velocity Space &Time SpaceTime

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Abstract

Light Velocity is a **constant of nature**, but not a constant like π. We consider distance and velocity as fundamental and time as merely a practical term. We relate to the **coordinate speed of light** of General Relativity (GR) [4] as a real variable speed. Space is a special frame, and velocity relative to it is measured by the CMB Doppler shift.

like the long-standing issue of Dark Matter

Keywords: Space; Time; SpaceTime; Light velocity; General relativity; Special relativity

1 A Brief History of Physics as We Understand it

1.1 Lorentz (1904)

Lorentz Ether Theory (LET) postulates a preferred universal reference frame, which is a stationary aether, unlike special relativity which does away with preferred reference frames. In LET, **Lorentz length Contraction** and **Larmor Time Dilation** are supposedly caused by motion through the aether. This length contraction was thought to be due to changes in electrostatic fields and molecular forces induced by the aether, so that it was a real physical phenomenon.

1.2 Einstein (1905)

Special Relativity (SR), for an homogenous and isotropic space and inertial systems (frames), is based on two postulates:

A. The laws of physics are invariant (identical) in all inertial frames of reference (that is, frames of reference with no acceleration).

B. The speed of light in vacuum is the same for all observers, regardless of the motion of light source or observer.

In SR **Lorentz length contraction** and **Larmor time dilation** are not real changes but merely an “observational” effect between reference frames.

Note that postulate A can be turned around to become a definition of **a low of physics**.

1.3 Einstein (1915)

Einstein abounded the concepts of **eater,** already in SR, and **vacuum** in General Relativity (GR). He replaced them by an elastic and fluidic **space**. Today we add to space the attribute of being cellular – a lattice. In GR space is affected by the presence of mass that distorts it and thus, causes space to become non-isotropic and non-homogeneous (deformed). **The possibility, however, that this deformation can affect light velocity has been ignored.**

1.4 Minkovsky (1908)

In **Special Relativity**, the **Minkowski SpaceTime** is a four-dimensional (three dimensions of space (x, y, z) and one dimension of time t) **manifold**. Spacetime has a metric signature of

(-+++), and describes a flat surface.

In SR length and time intervals are **relativistic**, whereas in SpaceTime the four-dimensional distance between two points (**events**) is the same for all moving observers (inertial frames). Thus, instead of the SR relativistic nature of reality of 3D space and 1D time we are back to the Newtonian reality of absolute 4D SpaceTime. SpaceTime is the "arena" in which all of the **events** in the universe take place.

The beauty of the SpaceTime concept weekend the interest to explore the possibility that light velocity **is not** a constant like π.

2 The Speed of Light as a Constant of Nature

Local observers in all zones of space, with or without gravitational fields, will claim to get the **same result** measuring light velocity with their standard yardsticks and clocks, that like space itself can change from place to place. Hence, we relate to Light Velocity as a **constant of nature.** However, each and every **faraway observer** [1] finds that, according to their observations, **coordinate light velocity** elsewhere [1], where local observers reside, might vary according to the gravitational fields in their locality. The common understanding, however, is that light velocity is a constant like π. We, in contrast, suggest to relate to the **coordinate speed of light** of GR [1] as a **real variable** speed of light (See Appendix A) dependent on the density of space, affected by the presence of mass (gravitational field).

The Meaning of the "Coordinate Speed of Light"

In general relativity the *local* speed of light is a constant and has the usual value c, but the speed of light that we "measure" *from here* for a part of space over *there* (called the coordinate speed) may differ from the accepted value.

This is a way to structure arguments about gravitational red/blue shift and the curvature of light paths. It is also a common way of explaining the Shapiro delay.

This point of view is successful enough that it is tempting to take it as definitive. To say:

The speed of light really does vary from place to place and the constancy of the local speed is an artifact of using the motion of light to define our measure of time.

With this understanding, we are able to resolve, as an example, the issue of Dark Matter.

Note that the **coordinate speed of light** is **slowed in the presence of gravitational fields,** see Appendix A.

3 Time and Distance

Time

We do not know what time is, we only know what motion is.

We can build devices called clocks; whose hand movement (or whatever is analogous to the hand movement) describes to us the "passing of time". The time of an event would be the position of the hands at the moment, and at the place of the event. The hands of the clock must move in a rhythmic circular motion so that each cycle is exact. In the case of a non-circular, but rhythmic motion the physical conditions must be preserved so that every motion is like the one preceding it. Thus, we can talk about the clock's rhythm, or frequency of its motions, where each cycle represents a unit of time.

Note that all the equations in physics are invariant to time reversal.

Distance

In a space lattice the distance between two points is simply the number of space cells on the straight line between the two points for a Euclidian space and on the geodesic for a deformed space.

4 The Metric and Light Velocity

Schwarzschild, in 1916, was the first to find a solution to Einstein's field equation - a general spacetime metric - for the exterior of a spherically-symmetric star of mass M and radius R. For $r > R$ according to Schutz [2] the line element ds^2 is:

$$ds^2 = - (1-2M/rc^2)\, c^2dt^2 + (1-2M/rc^2)^{-1}\, dr^2 + r^2\, d\Omega^2 \qquad \text{(10.36 in [5])} \qquad (1)$$

Note our added term c^2 in (1), according to old physics.

We denote a **gravitational scale factor**, a (see end of this section):

$$a = (1-2M/rc^2) \qquad (2)$$

For the surface of the sun or the edge of our galaxy:

$$GM/rc^2 \sim 10^{-6} \text{ and thus } GM/rc^2 << 1. \qquad (3)$$

For $GM/rc^2 << 1$ equation (2), for $r \to \infty$, is approximated as:

$$a \to 1 \tag{4}$$

We rewrite equation (1) to become:

$$ds^2 = -a^2c^2dt^2 + a^{-2}dr^2 + r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right) \tag{5}$$

The metric in equation (5) is derived by a **faraway observer** OB1 – far away from the center of a mass, M, that serves as the origin of their co-ordinates.

For OB1, a radial distance interval, dl, close to M, contains a smaller number of their yardstick units, dr, than dr_0, the number of the **local observer** OB2 yardstick units that dl contains. This is the result of the OB2 yardstick contraction (curving), which is the contraction of their local space. Hence:

$$dr_0 = a^{-1}dr \qquad a < 1 \tag{6}$$

From the **synchronization of clocks**, [6] Rindler arrives (p. 184) at:

$$dt_0 = adt \qquad a < 1 \tag{7}$$

Thus, for OB1, a time interval, $d\tau$, contains a larger number of time units, dt, than the number of time units, dt_0, for OB2.

The 4D **spacetime interval** between two events; the "emission" of a short pulse of light at point A and the "arrival" of this pulse at point B is:

$ds^2 = 0$.

Hence, using equation (5):

$$-a^2c^2dt^2 + a^{-2}dr^2 = 0 \tag{8}$$

$$acdt = a^{-1}dr \tag{9}$$

$$dr/dt = a^2c \tag{10}$$

This, $dr/dt = c'$, for OB1, is the light velocity close to a mass M. Light velocity, for OB1, far away from M, is c (standard light velocity), whereas $dr/dt = c' < c$.

This, $dr/dt = c'$, is a local, real and slower, light velocity since, according to equation (2), $a < 1$.

In the literature dr/dt in equation (10) is called **coordinate speed of light,** [1]. This is a misleading name, since dr/dt should be considered a **real speed.**

Substituting dr from equation (6) and dt from equation (7) in equation (8) gives:

$$dr/dt = adr_0/a^{-1}dt_0 = a^2dr_0/dt_0 \tag{11}$$

Comparing equation (11) to equation (10), gives:

$$dr_0/dt_0 = c \tag{12}$$

And from (11) again (See appendix A):

$$c' = a^2c \tag{13}$$

The results here verify that OB1 and OB2 measuring light velocity locally in their own zones of space arrive at the same result.

In conclusion:

$$dr_0 = a^{-1}dr \tag{6}$$

$$dt_0 = adt \tag{7}$$

$$c' = a^2c \tag{13}$$

The common consideration of **light velocity** as a constant like π is the main reason why Dark Matter is a long-standing issue for almost 100 years [3].

5 Summary

For local observers Light Velocity is a **constant of nature,** since their measuring tools change with their locality. **Faraway observers** find that, according to their observations, **coordinate**

light velocity elsewhere, where local observers reside, might vary according to the gravitational fields in their locality. To this velocity we relate as a real variable speed.

We consider distance and velocity as fundamental and time as merely a practical term. Considering the reality as a four-dimensional **SpaceTime** - three dimensions of space and one of time, is mathematically very esthetic and appealing but problematic. The immediate implication is on our understanding **light velocity, since time is considered fundamental.** Misunderstanding light velocity affects our ability to solve major open issues in physics,

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Appendix A On the Coordinate Light Velocity as a Real Velocity

The **permittivity** of the free space is ϵ_0 whereas in a deformed space it is: $\epsilon' = \epsilon\,\epsilon_0$ where ϵ is the relative permittivity due to the deformation.

The **permeability** of the free space is μ_0 whereas in a deformed space it is: $\mu' = \mu\,\mu_0$ where μ is the relative permeability due to the deformation.

Light velocity C, in a free space, according to the electromagnetic theory is:

$C^2 = 1/\epsilon_0\mu_0$ Whereas in a deformed space it is:

$C'^2 = 1/\epsilon'\mu' = 1/\epsilon\epsilon_0\,\mu\mu_0 = 1/\epsilon\mu \cdot 1/\epsilon_0\mu_0 = 1/\epsilon\mu\, C^2$

We have denoted a **gravitational scale factor**, a (related to space density). For a free space with no gravitational fields a = 1 whereas in a gravitational field (deformed space) a < 1.

For $1/\epsilon = a^2$ and $1/\mu = a^2$, which are pure numbers, we get:

$C'^2 = 1/\epsilon\mu\, C^2 = a^4 C^2$ or $C' = a^2 C$ which is relation (13) page 7.

Appendix B Two Fundamental Velocities

The Greek philosopher Zeno contended that there is **no motion**. In contrast, in our theory - the GeometroDynamic Model of the physical reality - GDM [4], there is **no rest**, and **only** two fundamental velocities exist.

The GDM considers the space lattice to be elastic with only two real fundamental velocities; that of transversal waves, and that of longitudinal waves. Transversal waves are shown to be the EM waves. Longitudinal waves are shown to be related to the inner motion in elementary particles (not discussed here) [4]. The Navier equation governs elastic media. Its solution for elastic transversal waves gives the expression for light velocity:

$$c' = \sqrt{(\mu/m)} \tag{B1}$$

where μ is a Lamé coefficient and m is the mass density of the media. Since space is massless, we take m as:

$$m = \epsilon_s / c^2 \tag{B2}$$

where ϵ_s is the standard space energy density, and c is the relevant light velocity. Inserting (B2) into (B1) gives:

$$c' = c\sqrt{(\mu/\epsilon_s)} \tag{B3}$$

Thus $[\mu] = [\epsilon_s]$, and we can rename the numerator and use ϵ instead of μ. Thus (B3) becomes:

$$c' = c\sqrt{(\epsilon/\epsilon_s)} \tag{B4}$$

By using (B2) we have turned (B1), an equation that determines c', into an equation (B4) that determines the ratio c'/c. But light velocity is determined by the permittivity and permeability of space and hence by the tension in the space cells. This tension is dependent on the energy per cell; hence the relation:

$$\epsilon/\epsilon_s = \rho_0/\rho \tag{B5}$$

where ρ is space density and ρ_0 is the standard space density - no deformations. Substituting (B5) in (B4) gives:

$$c' = c\sqrt{(\rho_0/\rho)} \tag{B6}$$

Every space disturbance, a transversal or longitudinal wavepacket, must move at the velocity c_T or c_L, respectively. We distinguish between c_T and c_L when necessary. In most cases we use the symbol c instead of c_T.

Appendix C The Cosmic Microwave Background (CMB)

At large, the CMB is isotropic and homogenous blackbody radiation, with a peak temperature of 2.7°k. The CMB was predicted theoretically by Gamow and discovered accidentally by Penzias and Wilson [5]. In 1989 the CMB was again measured, this time by the Cosmic Background Explorer (COBE) satellite [6], see Fig. (C1).An observer's motion relative to the background radiation is accompanied by a Doppler shift. This shift enables the measurement of the observer's velocity relative to the radiation bath "attached" (i.e., space's vibrations) to space.

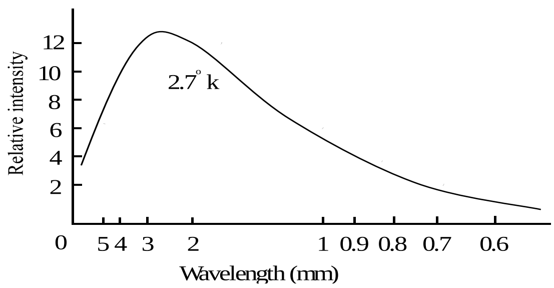

Fig. (C1) The Cosmic Background

Velocity Relative to Space

A CMB anisotropy was first observed by Smoot et al [6], and interpreted as the result of the above Doppler shift [7].

Fig. (C2) shows the vector of the velocity of planet Earth relative to the universe [8]. Recently, the velocity of the Earth around the Sun and its rotational velocity have been derived from the Doppler shift.

Earth's velocity relative to space is: $v = 371.0 \pm 0.5$ km sec^{-1}. This velocity is towards a point with equatorial coordinates: $(\alpha,\delta) = (11.20^h \pm 0.01^h,\ -7.22^0 \pm 0.08^0)$, [9]. This direction points from the cluster of galaxies, Aquarius, towards the cluster Leo-Virgo.

Say the peak of the background radiation is green. An observer, seeing green in all directions, knows they are at rest relative to space. An observer, seeing blue in one direction, red in the opposite direction, and green on the sides, knows they are moving in the direction of the blue.

Similarly, we can also make a distinction regarding acceleration.

An observer moving in a circle notice that, tangentially to the circle, there is no symmetry; the horizon in one direction looks red, and in the other, blue.

Coleman and Glashow [10], [11], also adopted this idea that space is a special frame.

The CMB necessarily “resides” in the same “stationary system”, which is the space lattice.

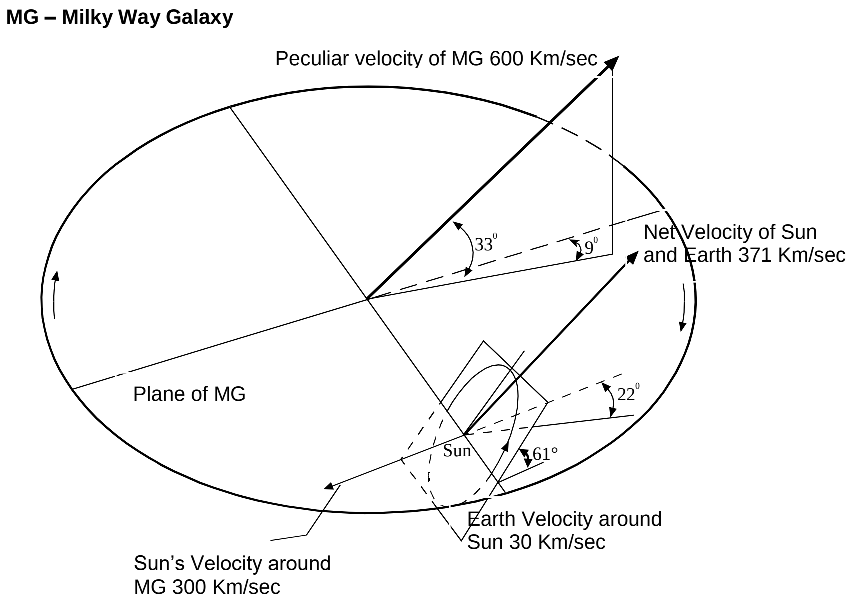

Fig. (C2) Earth Velocity Relative to the Space

Note that for observers on Earth, with velocity v relative to the space frame, $v \ll c$, and

$\gamma \sim 1+1/2\cdot v^2/c^2 \sim 1+ 3\cdot 10^{-7}$. Thus, ignoring $3\cdot 10^{-7}$ and taking $\gamma = 1$, we are left with the SR notion that only relative velocity matters, as if there is no special frame.