THE POSTULATE "INVARIANCE OF THE SPEED OF LIGHT"

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Abstract

The change of the units *second* and *metre* and the constant *speed of light* between two "*time-spatial domains*" with different gravitational potentials is considered in the article. It is analyzed as a consequence of the nature of space and time which are mutually connected with each other in the warped space-time of the Universe.

The main topic of the article is:

The postulate "Invariance of the speed of light" is proposed to be changed with "Uncertainty principle of the macro-world".

Some consequences of the approach used in this article could be simple solutions of problems such as "the accelerated expansion of the Universe", as well as "the dark matter and the dark energy in the Universe", which have been under research for a long time.

Keywords: *postulate of speed of light, uncertainty principle, Special Relativity, General Relativity, units, gravitational potential, light propagation, electromagnetic radiation.*

1. Introduction

"The formulation of a given problem is far more essential, than its decision that could be simply a question of mathematical or experimental skills. In order to bring up new questions, to indicate new capabilities, to look at old problems under a new angle, a creative imagination is required. That is what marks the real advance in science".

Albert Einstein, Leopold Infeld, "Evolution of Physics ", 1938

The Special Theory of Relativity applies to homogeneous field without gravity and is based on the principle of relativity and the postulate of the constancy of the speed of light.

„We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body" [1)].

In this definition Einstein does not affect the influence of the movement of the Observer's reference system on the measured speed of light. It is refuted a long ago that the speed of light is independent from the movement of the Observer's reference system. The dependence of the measured speed of light is demonstrated in various experiments by Sagnac, Georges [2)]; Michelson, A.A. and Gale H.E [3)], Miller, D.C.[4)], Marmet, P. [5)], Ashby N. [6)], Kelly, A. [7)], Gift, S.J.G. [8)]. The results of these experiments are explained in Sharlanov, G.V. [9)]. They prove that the speed of light is different in different directions in the reference system associated with the moving Earth's surface, but constant in the reference system associated with the space itself, where the light spreads. All of these experiments are carried out in the time-spatial domain with equal gravitational potential such as the area near the Earth's surface. Today the GPS utilizes a clock-synchronization procedure based on invariance of **c** in vacuum and "Sagnac correction". This procedure is developed on the base of published standards and synchronization rules.

So the reader should be aware that in this article the behavior of light is concerned **only in the reference system connected to the space itself**, where the light emits, absorbs and spreads. In this reference system the speed of light is constant and it is a fact only if the time-spatial area is with the equal gravitational potential (the equal level of contraction/expansion of the space-time).

This article discusses:

- how the speed of light in vacuum (in the reference system associated with the space itself) changes with the change of the gravitational potential (or with the change of the level of expansion/contraction of the space-time).
- why the change of the speed of light in the reference system associated with the space itself cannot be determined (or true values of that change cannot be obtained, as a result of measurement in a certain point of time). Or the change of the speed of light cannot be determined in the small time-spatial

domain, where the SI based units of time and length have been defined and where the experiment is carried out.

- To sum up as a logical consequence of this discussion is a proposed "Uncertainty principle of the macro-world".

Our units are only for our "*small spatial domain*"[10]. Furthermore, the level of contraction/expansion of the time-space continuously changes in each time-spatial domain (the Universe is not static), but it cannot be understood.

A lot of cases of contradictory results, which are often named "*singularity*" or "*strangenesses*", are because of not specifying:

- the standards and units in the location of the experiment and in the location of the Observer (their distinguishing);
- the way of the unit definitions of the SI base units *second* and *metre* (of the *time* and *length*);
- what are the initial conditions and their influence on the results.

2. Definitions of the Base Units "metre" and "second" in International System of Units "SI"

2.1. About the definitions of the SI base units in the framework of general relativity

Overall, the definitions of the standards in "SI" in the framework of general relativity are written in the *„SI brochure 8th edt./BIPM 2006"*:

"The definitions of the base units of the SI were adopted in a context that takes no account of relativistic effects. When such account is taken, it is clear that the definitions apply only in a small spatial domain sharing the motion of the standards that realize them. These units are known as proper units; they are realized from local experiments in which the relativistic effects that need to be taken into account are those of special relativity." [10]

2.2. Definitions of the SI base units "second" and "metre" (of time and length) in the International System of Units "SI"

- *'Second'*, the SI base unit of time.

The 13th CGPM (1967-1968, Resolution 1) replaced the definition of the second by the following:
"The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom." [11]

At its 1997 meeting, the BIPM affirmed that:
"This definition refers to a caesium atom at rest at a temperature of 0°K." [12]

Convention: Let's name this radiation of the caesium 133 atom as *standard radiation*, and ν_s and λ_s are the frequency and wavelength of this *standard radiation*.

- *'Metre'*, the SI base unit of length.

The definition of *metre* since 1889, based on the international Prototype of platinum-iridium, is abrogated with Resolution 6 of the 11th meeting of CGPM (1960). The definition of the metre was replaced by the following:
"The metre is the length equal to 1650763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton 86 atom." [13]

Since 1983, by the 17th CGPM (Resolution 1) *the metre is* replaced *as:*
"The metre is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second." [14]
This definition is based on the postulate "*Invariance of c (speed of light)*".

The symbol $\mathbf{c_o}$ (or sometimes simply **c**), is the conventional symbol for the speed of light in vacuum.
The value of the *speed of light* is recommended in 1975 by the 15th CGPM in its Resolution 2: *"[CGPM] recommends the use of the resulting value for the speed of propagation of electromagnetic waves in vacuum c = 299 792 458 metres per second."* [15]

Here it should be noted that the definition of the units *"second"* [11] and "*metre*" [13] are associated with the coordinate system of the space itself. However, in 1983 the definition of the unit *"metre"* [14] was replaced by using the constant *speed of light*. Therefore the speed of light should be defined also in the coordinate system associated with the space, not in the coordinate system associated with the Earth's surface. One of the methods by which the speed of light can be defined in the coordinate system associated with the space, is by taking the arithmetical average of the measured velocities in two opposite directions (East-West) in the coordinate system associated with the Earth's surface.

This note is directed to the current definition of unit "meter" of BIMP and gives a proposal for a more accurate measurement of "the speed of light in vacuum" - relative to Resolution 2 of the 15th meeting of the CGPM (1975) [15].

3. Definitions of the SI Base Units "Metre" and "Second" by Means of an Identical Experiment - by Means of the Same "Standard Radiation"

In fact, the *definition of a unit* means that the exact definite experiment is carried out at exact definite initial conditions. As a result of this experiment, a certain NUMBER is fixed which is defined as *unit* and is given a name.

No discrepancy and/or contradictions will be encountered, if we accept, that the SI base units *second* and *metre* (of *time* and *length*) are defined as a result of an experiment on the base of one *standard electromagnetic radiation* - the same *standard radiation*, which we use for definition of the *second*. This way of defining the SI base units *second* and *metre* is convenient for easier understanding of the main idea by readers, when the standards and units in time-spatial areas (domains) with different gravitational potential are compared; and because in this way the units *second* and *metre* are defined in the coordinate system of the space itself.

Following this approach, let us define the *metre* as:

the length, equal to 30.66331899 wavelengths of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom in a vacuum, at rest, at a temperature of 0°K.

By means of fixing of 30.66331899 wavelengths of this *standard radiation*, we can define our *unit* of length, and we can call it a *metre*. Or *one metre* we match with the number 30.66331899 as a result of that exact definite experiment.

In this way, if for our *"standard radiation"* the number of periods per *second* is exactly N_s=*9 192 631 770;* the number of wavelengths per *metre* is exactly N_m=*30.66331899* - and the constant "*speed of light"* will be the exact value (number):

$$c = N_s/N_m = 9\,192\,631\,770 / 30.66331899 = 299\,792\,458\ [m/s] \qquad (1)$$

4. The Postulate "Invariance of the Speed of Sight" - Two Reasons why the Change of the Speed of Light cannot be Determined

4.1. (Well-known) Consequences:

If we look at the article by Albert Einstein [16] *in its nature, the following scenarios (A and B) are in effect*:

A) at taking off from the surface of a star and entering interstellar (more expanded) space, the frequency of electromagnetic radiation increases, and so does the speed of light (according to §*3.Time and the Velocity of Light in the Gravitational Field* [16]):

"... we must use clocks of unlike constitution for measuring time at places with differing gravitation potential.

For measuring time at a place which, relatively to the origin of the co-ordinates, has the gravitation potential ***Φ****, we must employ a clock which – when removed to the origin of co-ordinates – goes* ***(1 + Φ/c²)*** *times more slowly than the clock used for measuring time at the origin of co-ordinates."* [16]

The frequency in a location that has the gravitation potential **Φ** relative to the origin of the co-ordinates will be higher, but measured by the units defined in the origin of the co-ordinates:

$$\nu = \nu_0\left(1+\frac{\Phi}{c^2}\right) \quad {}^{16)} \qquad (2)$$

Here the *speed of light* **c** is a constant. Further in the article, Einstein states:

„If we call the speed of light at the origin of co-ordinates c_0*, then the speed of light* **c** *at a place with the gravitation potential* ***Φ*** *will be given by the relation:*

$$c = c_0\left(1+\frac{\Phi}{c^2}\right) \quad [16] \qquad (3)$$

The principle of the constancy of the speed of light holds good according to this theory in a different form from the one that usually underlies the ordinary theory of relativity." [16]

Also according to the General Relativity, in the locations with greater expansion of the space:

- The time goes faster (which is the consequence of increasing the frequency of the electromagnetic radiation – the *second* becomes shorter).
- The *meter* becomes longer (the wavelength of the electromagnetic radiation increases).

B) Vice-versa, (according to Einstein's paper [16]), when approaching the Earth's surface, the frequency of electromagnetic radiation decreases, and respectively so does the speed of light.

Moreover, according to the General Relativity, in the locations with greater collapsing of the space:

- The time goes slower (which is consequence of decreasing the frequency of the electromagnetic radiation/*second* becomes longer).
- The *meter* becomes shorter (the wavelength of the electromagnetic radiation decreases).

The change of the *meter* however is not taken into consideration in the equations (2) and (3) by Einstein. If this change was set into **Φ** and **c** - the result would be uncertainty (see below 6. Uncertainty principle for the macro-world).

Summary: At the emission, spreading and absorption of any electromagnetic radiation, its frequency and wavelength are in synchrony with the time-space distortion (curvature) of the "space-time domains" where the light emits, passes or absorbs.

4.2. The first reason why the change of the speed of light cannot be determined: The „way of definition" of the SI base units of length and time ("metre" and "second")

The case under consideration:

4.2.1. Initial conditions

(i) Let's look at two local small time-spatial areas (domains) - one is $\mathbf{D_1}$, and the other is $\mathbf{D_2}$, in the real warped time-space of our Universe. Let them generally have different gravitational potential (different level of contraction/expansion of the time-space) and the gravitational potential of $\mathbf{D_2}$ is higher than gravitational potential of $\mathbf{D_1}$, or ($\mathbf{\Phi_2>\Phi_1}$).

(ii) The SI base units - *second* and *metre* are defined in $\mathbf{D_1}$ and $\mathbf{D_2}$ through the same experiment (under **3**.) - using the *standard radiation*, corresponding to the transition between the same two hyperfine levels of the *Cesium-133* atom.

In this way by fixing the same numbers N_s and N_m , the units of the length and time in the two domains will be different ($\mathbf{\Phi_2>\Phi_1}$), because the frequency and the wavelength are different, but the calculated speed of light will be the same (1).

4.2.2. Analysis

Convention: „The subscript indicates in what domain the measurement is carried out and the superscript indicates the domain where the unit is defined".

Let us name the unit of time, obtained by measuring the duration of N_s*=9 192 631 770* periods of the *standard radiation* in $\mathbf{D_1}$ *second-1,* and in $\mathbf{D_2}$ – respectively *second-2***.** Obviously *second-1* will be with longer duration than *second-2,* because the gravitational potential of $\mathbf{D_2}$ in relation to $\mathbf{D_1}$ is ($\mathbf{\Phi_2> \Phi_1}$) - or the time in $\mathbf{D_1}$ passes more slowly.

Let us name the unit of length, obtained by measuring the length of N_m*=30.66331899* wavelengths of *standard radiation* in $\mathbf{D_1}$ *metre-1,* and in $\mathbf{D_2}$ – respectively *metre-2***.** Obviously *metre-2* will be longer than *metre-1,* because the gravitational potential of $\mathbf{D_2}$ in relation to $\mathbf{D_1}$ is $\mathbf{\Phi_2 > \Phi_1}$ - or the space in $\mathbf{D_2}$ is more expanded than the space in $\mathbf{D_1}$ **.**

The results are:

- Measuring the frequency and the wavelength of the *standard radiation* in domain $\mathbf{D_1}$**,** but with the units *second-2* and *metre-2* defined in domain $\mathbf{D_2}$, where $\mathbf{\Phi_2 > \Phi_1}$" – the obtained results will be ($\mathbf{\nu_{s1}^2}$ and $\mathbf{\lambda_{s1}^2}$).

When measuring the frequency and the wavelength of the *standard radiation* in $\mathbf{D_1}$ with the units defined in $\mathbf{D_2}$ (where the *metre* is longer, but the *second* is shorter than those in $\mathbf{D_1}$), the results (values) will occur to be smaller than those measured with their own units defined in time-spatial domain $\mathbf{D_1}$:

$$\nu_{s1}^{2} < \nu_{s1}^{1} \quad \text{and} \quad \lambda_{s1}^{2} < \lambda_{s1}^{1} \tag{4}$$

The resulting value (number) of measurement of the *speed of light* in domain $\mathbf{D_1}$ with the units defined in $\mathbf{D_2}$, will be much less if we were using the units defined within the domain $\mathbf{D_1}$:

$$c_1^{2} = \nu_{s1}^{2} \, . \, \lambda_{s1}^{2} << \nu_{s1}^{1} \, . \, \lambda_{s1}^{1} = c_1^{1} = \mathbf{299\ 792\ 458} \ \text{[m/s]} \tag{5}$$

- Measuring the frequency and the wavelength of the *standard radiation* in domain $\mathbf{D_2}$, but with the units *second-1* and *metre-1* defined in domain $\mathbf{D_1}$, where $\Phi_1 < \Phi_2$ – the obtained results will be (ν_{s2}^{1} and λ_{s2}^{1}).

Respectively, when measuring frequency and the wavelength of the *standard radiation* in $\mathbf{D_2}$ with the units for $\mathbf{D_1}$ (where the *metre* is shorter, but the *second* is longer than those in $\mathbf{D_2}$), the results (values) will occur to be bigger than those measured with their own units defined in time-spatial domain $\mathbf{D_2}$:

$$\nu_{s2}^{1} > \nu_{s2}^{2} \quad \text{and} \quad \lambda_{s2}^{1} > \lambda_{s2}^{2} \tag{6}$$

When the measurement of the *speed of light* in domain $\mathbf{D_2}$ is made with the units defined in $\mathbf{D_1}$, the resulting value (number) will be much bigger if we were using the units defined within the domain $\mathbf{D_2}$:

$$c_2^{1} = \lambda_{s2}^{1} . \nu_{s2}^{1} >> \lambda_{s2}^{2} . \nu_{s2}^{2} = c_2^{2} = \mathbf{299\ 792\ 458} \ \text{[m/s]} \tag{7}$$

Summary: Therefore, measuring the speed of light in two domains with different gravitational potentials, respectively Φ_1 of D_1 and Φ_2 of D_2, ($\Phi_2 > \Phi_1$), but with the units defined in only one of domains, the much greater speed of light in D_2 will be confirmed in the two above mentioned points of view (the two cases of measuring – (5) and (7)).

- But if someone measures the frequency ν_s and the wavelength λ_s of the *standard radiation* in $\mathbf{D_1}$ and in $\mathbf{D_2}$ with their own units (defined in their time-spatial domains), he will obtain the same value.

$$\nu_{s1}^{1} = \nu_{s2}^{2} \quad \text{and} \quad \lambda_{s1}^{1} = \lambda_{s2}^{2} \tag{8}$$

although the frequency and the wavelength of *standard radiation* in $\mathbf{D_1}$ are less than in $\mathbf{D_2}$.

Respectively, if someone measures *speed of light* c_1 in domain $\mathbf{D_1}$, and c_2 in domain $\mathbf{D_2}$ with their own units defined in their time-spatial domains, he will obtain the same value (will have the same number), or:

$$c_1^{1} = c_2^{2} = N_s/N_m = 9192631770/30.66331899 = 299\ 792\ 458 \ \text{[m/s]} \tag{9}$$

And all of this is in spite of the fact, that the units *metre* and *second* in the two domains are different and the *speed of light* is different, too.

4.2.3. Summary of the analysis

- In spite of the fact that the SI base units (*metre* and *second*) are different in two domains with different gravitational potential (or with different level of contraction/expansion), the measurement results for the *frequency* and *wavelength* of the *standard radiation* into the two domains will be the same. This is because the SI base units (*metre* and *second*) are defined in these two domains on the base of identical experiments by means of the same electromagnetic radiation.

- The difference of *speed of light* cannot be determined into the domains with different gravitational potential (or with different level of contraction/expansion), because the change of the base units of the SI (*second* and *metre*) cannot be determined.

- Further more, if we choose another *"standard radiation"* - different from previous electromagnetic radiation and if we define the SI base units of time and length (the *second* and *metre*) through the same experiment, (fixing the same numbers N_s and N_m) - we will measure the same result for the *speed of light* (1) in spite of the fact, that the units *metre* and *second* are different.

Summary: The change of *speed of light* cannot be determined in case of changing the gravitational potential (or in case of changing the level of contraction/ expansion) of the domain where the observer is located and where the units are defined.

4.3. Second Reason why the change of the speed of light cannot be determined: The synchronous change of all local constants and all SI base and derived units (of the entire Physical Reality) at changing the level of contraction/expansion of space-time

4.3.1. Awareness of the space-time and the electromagnetic radiation as a vibration of the space-time itself

The space-time itself is often called a vacuum. The space-time exists on many levels - it is among the elementary particles of the matter, among all the planets, stars and galaxies. All these levels are mutually interconnected, depending on each other, and changing in full and perfect synchrony and harmony. The space-time is curved, bended and warped at a micro and at a macro-level – curved, bended and warped by the smallest particles of matter (like nucleus of the atom), by the planets, stars, galaxies... in all areas of the Universe.
The electromagnetic radiation itself originates in the reference system of the space itself as a vibration generated at the transition of the electrons from one level of space and energy to another. The electromagnetic radiation spreads in the space-time vibrating in synchrony with the level of the contraction/expansion of the space-time and is absorbed in the space-time (again at the transition of electrons from one space level to another giving energy to electrons). Therefore, we should realize that all spectrum of electromagnetic radiation is a type of vibration of the space-time itself and all the spectrum changes its parameters and characteristics in full synchronization with the curved, bended and warped space-time. On one hand, this synchronization means that the electromagnetic radiations are oppressed (overwhelmed) in a strong gravitational field (at a high level of contraction of the space-time). They transform themselves into vibrations with shorter wavelengths and with lower frequencies, which means lower speed of spreading. On the other hand, when the electromagnetic radiation enters into weak gravitational field (higher level of expansion of space-time), the wavelengths of electromagnetic vibrations become longer and frequencies become higher, which means a higher speed of spreading. The explanation of the anomaly in the acceleration of spaceships "Pioneer-10&11" at the border of the Solar system – is actually a proving experiment of this hypothesis [9)].

4.3.2 Awareness of the speed of light as a coefficient of correlation between wavelength and the frequency of any electromagnetic radiation in a time-spatial domain with a certain level of contraction/expansion

In other words, the wavelength and the frequency of any electromagnetic radiation are mutually connected with a coefficient of correlation which we call the speed of light. This coefficient is a local constant for the any time-spatial domain with any level of contraction/expansion of the time-space. This local constant (the speed of light) is different for the time-spatial domains with different level of contraction/expansion, but it is not possible to determine this change – the measured value of this coefficient is always the same, because the units of time and length are defined through the wavelength and the frequency of electromagnetic radiation.

Not only the speed of light, but all the local constants and all the SI based and derived units (all the local units) synchronously change with the changing of the level of contraction/expansion of space-time**. It means a change of the entire Physical Reality** - the entire Physical Reality is changing with the change of contraction / expansion of the space-time.

It means, for example, that the change of the unit *metre*, defined as a length equal to certain number of wavelengths of electromagnetic radiation in vacuum" is fully synchronous with the change of "*the metre Prototype of platinum-iridium*" with the change of contraction/expansion of the space-time. Or „the metre -the Prototype of platinum-iridium" is changing synchronously with changing the wavelength of any electromagnetic radiation.

5. Conclusions

Conclusion 1: <u>In the reference system associated with the space itself where the light is actually spreading - it is not possible to prove by measurement (getting true and valid values as a result of this measurement), carried out at a certain time, that there is a change of the value of the speed of light in the time-spatial domain where the SI based units of time and length are defined.</u>

This is the result of the above mentioned two reasons:

- The *way of definition* of the SI base units (*metre* and second), based on identical experiments through electromagnetic radiation, through interrelated characteristics of the electromagnetic radiation (of the light);

- The *synchronous change* of the entire physical Reality at changing the level of contraction/expansion of the space-time.

Furthermore, indeterminacy is not only for the constant *speed of light*:

Conclusion 2: In the reference system associated with space itself, where the light is actually spreading - it is not possible to prove by measurement the change of the value of any physical constant (the speed of light, Planck's constant, etc.) in the time-spatial domain where physical units are defined.

6. Uncertainty principle for the macro-world

The nature of space-time itself is mutual, general and interrelated relativity of all the micro- and macro-levels in the Universe!

Instead of the postulate ***Invariance of c*** **-** the ***Uncertainty principle for the macro-world*** should be approved:

The uncertainty of the macro-world consists in the fact, that we cannot measure or calculate neither the change of the defined by us units, nor the change of all our local constants, because they all change in perfect synchronization with the change of the entire physical reality. Also, we cannot measure or calculate the exact change of the entire physical reality of another remote time-spatial domain with different level of contraction/expansion of the space-time.

Some consequences are:

Statement 1: The accuracy of the measurement or calculation (even in theory) of the DISTANCE to a "time-spatial domain" (or to an object in the Universe) is in inverse proportion:

- to the remoteness and
- to the relative level of contraction/expansion of the "time-spatial domain" in comparison with that of the Observer.

Statement 2: The accuracy of the measurement or calculation (even in theory) of the TRAVEL TIME OF THE LIGHT from a "time-spatial domain" (or an object in the Universe) is in inverse proportion:

- to the remoteness and
- to the relative level of contraction/expansion of the "time-spatial domain" in comparison with that of the Observer

The remoteness introduces inaccurate information at its transmission (a shift due to the change of time while carrying it);

The relative level of contraction/expansion between "time-spatial domains" of the Object and Experimenter introduces inaccurate information due to the change of the base units of time and length.

All this is due to the nature of space and time, which are intimately and mutually connected with each other in all levels of the curved, bended and warped space-time of the Universe.

This is also the "Border of the Experimental Provability"...

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