The Influence of Gravitation on the Speed of Light and an Explanation of the Pioneer 10 & 11 Acceleration Anomaly

Gocho V. Sharlanov
Stara Zagora, Bulgaria 6014, EU
E-mail: gsharlanov@yahoo.com; gsharlanov@engineer.bg

Received: August 15, 2011 Accepted: August 29, 2011 Published: November 1, 2011
doi:10.5539/apr.v3n2p241 URL: http://dx.doi.org/10.5539/apr.v3n2p241

Abstract

Constancy of the speed of light in time-spatial area with the same gravitational potential (or in time-spatial area with equal level of contraction/expansion of the space-time) is demonstrated. All of the experiments ("One-way", "Two-way" and "Multiple-way" measurements) are made in time-spatial area with the same gravitational potential (or in time-spatial area with equal level of contraction/expansion of the space-time) – this is the Earth's surface. Explanation that there is no change in the value of the speed of light in all of the above mentioned experiments is given.

The speed of light (or of the electromagnetic radiation) is changing only when the light passes through time-spatial areas with different gravitational potentials (or in time-spatial areas with different levels of contraction/expansion of the space-time). The Pioneer 10 and 11 Acceleration Anomaly is actually a proving experiment of this reality.

Keywords: Speed of light, Constancy, One-way, Two-way, Light measurement, Special relativity, Pioneer 10, Pioneer 11, Acceleration anomaly, General relativity

1. Introduction

For more than ninety years, many experiments have shown that the speed of light is not constant. Some of the most popular experiments are described by Sagnac, G. (1914), (Michelson, A.A,1925). and (Gale, H.E., 1925), (Miller, D.C.,1933), (Marmet, P.,2000), (Kelly, A., 2005), (Gift, S.J.G., 2010). In all of these experiments, the reference coordinate system is associated with the Earth's surface and the results are light speed angular dependence anisotropy.

The results of the "one-way" measurements of the speed of light, given in the paper (Gift, S.J.G., 2010), (which is analyzed in the next point of the article), also show that if we associate the reference coordinate system with the Earth's surface, we get light speed anisotropy results. However, the light is propagated in the space. That is why, it is correct to associate the reference coordinate system with the space itself, where the Earth moves and warps the space around. In this reference coordinate system, the light goes through paths with different lengths, depending on the direction.

2. One-Way Light Speed Determination - Another point of view

The range management equation is very important to the operation of GPS. Let us examine "One-Way" light speed determination which is done in the paper of (Gift, S.J.G., 2010) "One-Way Light Speed Determination Using the Range Measurement Equation of the GPS", using the same designations. The transmitter, the receiver and the traveling path (trajectory of the light) are in a spatial domain with the same gravitational potential. The transmission and reception stations are moving eastward at the speed V of the Earth's surface at the same latitude. On an axis fixed in the Earth-Centered Inertial frame along the line joining the two stations with the origin west of station A, the position of station A is $X_A(t)$ at time t and the position of station B is $X_B(t)$.

2.1 The case "Eastward Transmission"

The station A transmits a signal eastward at time t_I to station B which receives it at time t_F. Then, the light passes a particular path in the space (from the moment of transmission t_I to the moment of receiving t_F, from the point $X_A(t_I)$ to the $X_B(t_F)$) – look at Fig.1. This path is equal to the distance between the two stations D plus the

distance Δ that the station B has passed during the time interval (t_F–t_I) at the speed V:

$$(t_F - t_I) = \frac{Path}{c} = \frac{D+\Delta}{c} = \frac{D+V*(t_F - t_I)}{c} \tag{1}$$

As a result we get the expression:

$$(t_F - t_I) = \frac{D}{c-V} \tag{2}$$

On the base of this equation the speed of the light was claimed to be equal to (c-V). But the right interpretation of (2) is: if the light has traveled the path D during the time interval (t_F–t_I), then its speed would be (c-V). However, the real path in the space is (D+Δ) and in the space where the light is propagated, the speed of light appears to be constant.

2.2 The case "Westward Transmission"

The station A transmits a signal westward at time t_I to station B which receives it at time t_F. In this case we apply the same approach. Then, the light passes a particular path in the space (from the moment of transmission t_I to the moment of receiving t_F, from the point $X_A(t_I)$ to the $X_B(t_F)$) – look at Fig.2. This path is equal to the distance between the two stations D minus the distance Δ that the station B has passed in the space during the time interval (t_F–t_I) at the speed V:

$$(t_F - t_I) = \frac{Path}{c} = \frac{D-\Delta}{c} = \frac{D-V*(t_F - t_I)}{c} \tag{3}$$

$$(t_F - t_I) = \frac{D}{c+V} \tag{4}$$

The interpretation of (4) is not that the speed of the light is equal to (c+V). Indeed, if the light has traveled the path D during the time interval (t_F–t_I), then its speed would be (c+V). However, the real path of light in the space is (D-Δ) and in the space where it is propagated (the spatial domain with the constant gravitational potential) - the speed of the light is constant.

Or in the two cases the light travels different paths during different time intervals (t_F–t_I), but with a constant speed of light.

3. Two-Way Light Speed Ascertainment. "Michelson-Morley Experiment" Analysis

Let us apply the same approach - to associate reference coordinate system with the space itself, where the Earth moves and warps the space around. The objects of the sets of „Michelson-Morley Experiment" (and also the Ether-Drift Experiment of D.C. Miller) are at the same gravitational potential - at the Earth's surface. Therefore, the speed of light is constant.

The interferometer used in „Michelson-Morley" experiment – see Fig.3:

- The light source, detector, "SSM" (Semi-silvered mirror) and the mirrors are horizontally located (at the same gravitational potential).
- The SSM, mirror A and mirror B are in the general case at the different latitudes (L_{SSM}, L_A and L_B) with the corresponding speed of the Earth's surface (V_{SSM}, V_A and V_B).

If the distances between (SSM-Mirror A) and (SSM-Mirror B) are D, the lengths of the "Two-way path" which the light passes between (SSM-Mirror A) and (SSM-Mirror B) will depend on Δ, which will be different (V_{SSM}, V_A and V_B are different) and this difference will change as the angle α (the orientation of the set of the experiment) changes. That is why, the change of the speed of light will be registered in the Earth-Centered Inertial reference frame. This difference is too small to detect, but in case of "Multiple-way path", obtained by the D.C.Mill's Interferometer, the difference grows repeatedly.

For example, in the special case of these experiments, when $\alpha=45^0$ or $\alpha=225^0$ (see Fig.3) the latitudes of the mirror A and mirror B are equal and we will have the same path of the light in the space. Hence, in this particular case even if we use D.C.Mill's Interferometer (associated with the Earth-Centered Inertial reference frame), the change of the speed of light cannot be registered.

In all of the above mentioned cases, the objects of the sets of the experiments are at the same gravitational potential. The potentials of these objects in relation to the Sun and their potentials to the global location of the

Solar system in the Galaxy can be ignored, because the gravitation to the Earth is dominant.

According to the article by Albert Einstein "*On the Influence of Gravitation on the Propagation of Light*", the speed of light is different in its passage through the time-spatial domains with different gravitational potential:

If we call the speed of light at the origin of co-ordinates $\boldsymbol{c_0}$*, then the speed of light* $\boldsymbol{c}$ *at a place with the gravitation potential* $\boldsymbol{\Phi}$ *will be given by the relation:*

$$c = c_0\left(1 + \frac{\Phi}{c^2}\right) \tag{5}$$

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."

This approach also gives an explanation for the Pioneer 10 and 11 Acceleration Anomaly. The total gravitational potential (or the level of contraction/expansion of the space-time) of certain small spatial domain in the Universe corresponds to the GULW (Global Universe Level of Warping), or to the contraction/expansion of the space-time of this domain. The speed of light increases/decreases in correspondence with GULW of the spatial domains in the Universe, through which the light or electromagnetic radiation passes. Or in any time-spatial domain in the Solar system, GULW depends on (GL_P+GL_S+GL_G), where GL_P is this level depending on the gravitational potential related to the nearest planet; GL_S is this level depending on the gravitational potential related to the Sun; and GL_G is this level depending on the gravitational potential related to the current location of the Solar system in the Galaxy.

4. Discussion

The observed anomaly of the acceleration of the spaceships Pioneer 10 and Pioneer 11 is because of the fact that the communicational signals between spacecraft and Earth (the electromagnetic radiation) are with much higher speed (and increasing) when the spaceships escape from the Sun gravity.

Furthermore, the part of trajectory of the communicational electromagnetic signals from the spaceship to the Earth, in which the speed of light is much higher than the speed of light at the Earth surface, is increasing too.

As a result, the expected travel time of the communicational electromagnetic signals (based on the constancy of the speed of electromagnetic radiation) between the spacecraft and Earth turns out to be much more than the real travel time. So we register backward attraction (acceleration) of the ship to the Sun.

This explanation of the Pioneer 10 and 11 Acceleration Anomaly is actually another test of Einstein's conclusion in his article "*On the Influence of Gravitation on the Propagation of Light*"**.**

5. Conclusion

- Actually, this paper gives a new explanation of discrepant results about the constancy of the speed of light, unambiguously obtained from the "one-way", "two-way" and "multiple-way" measurement experiments.
- The speed of the light is changing only as a result of the change in the gravitational potential (or the change of contraction/expansion of the space).
- Another new contribution is the acceptance that the "ether" is considered to be the "warped space-time of the Universe" itself. It is true that for more than 100 years scientists make experiments to discover existence of the "ether".

Notes:

- The Special Relativity is based on the postulate of the constancy of the speed of light – at the same gravitational potential, but regardless of the reference system. That is why, the Special Relativity has to be revised.
- We have to develop a new interpretation of the General Relativity based on the **"**Uncertainty principle of the macro-world**"** suggested by (Sharlanov, G.V., 2011). As a consequence, this article (*The postulate "Invariance of the Speed of Light"*) will give a solution of problems such as "the accelerated expansion of the Universe", as well as the explanation of the dark matter and the dark energy in the Universe, which has been under research for a long time.

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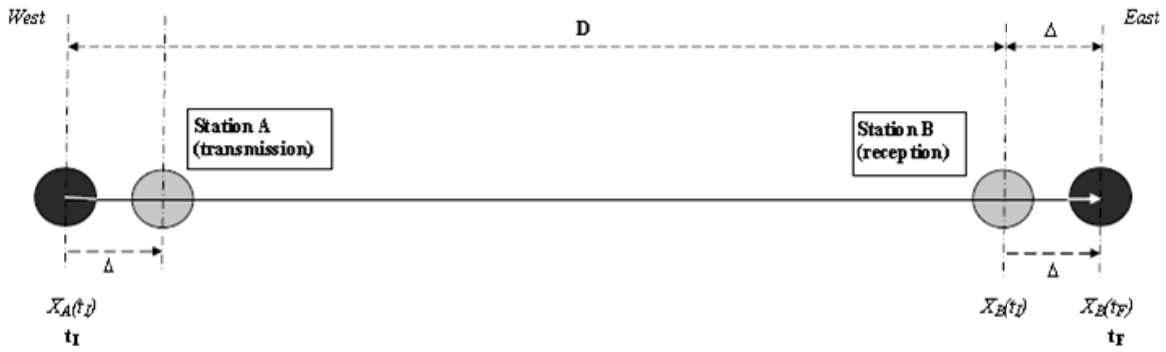

Figure 1.

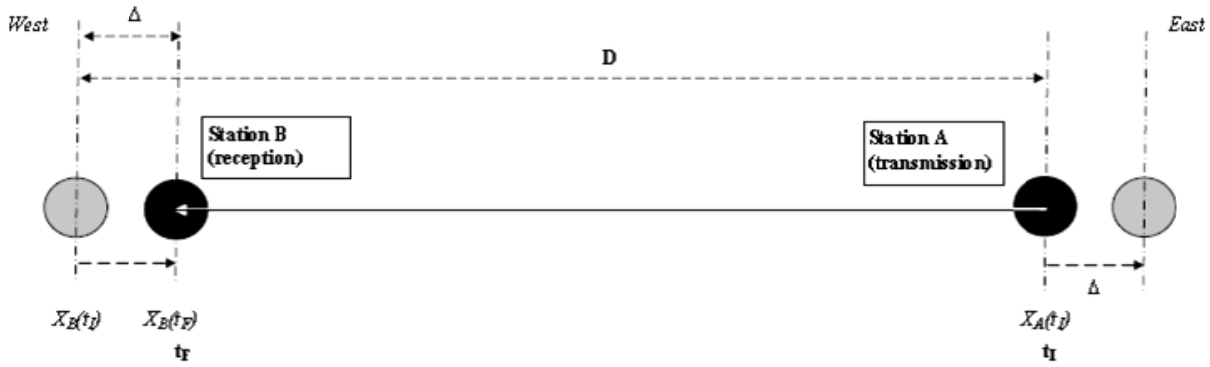

Figure 2.

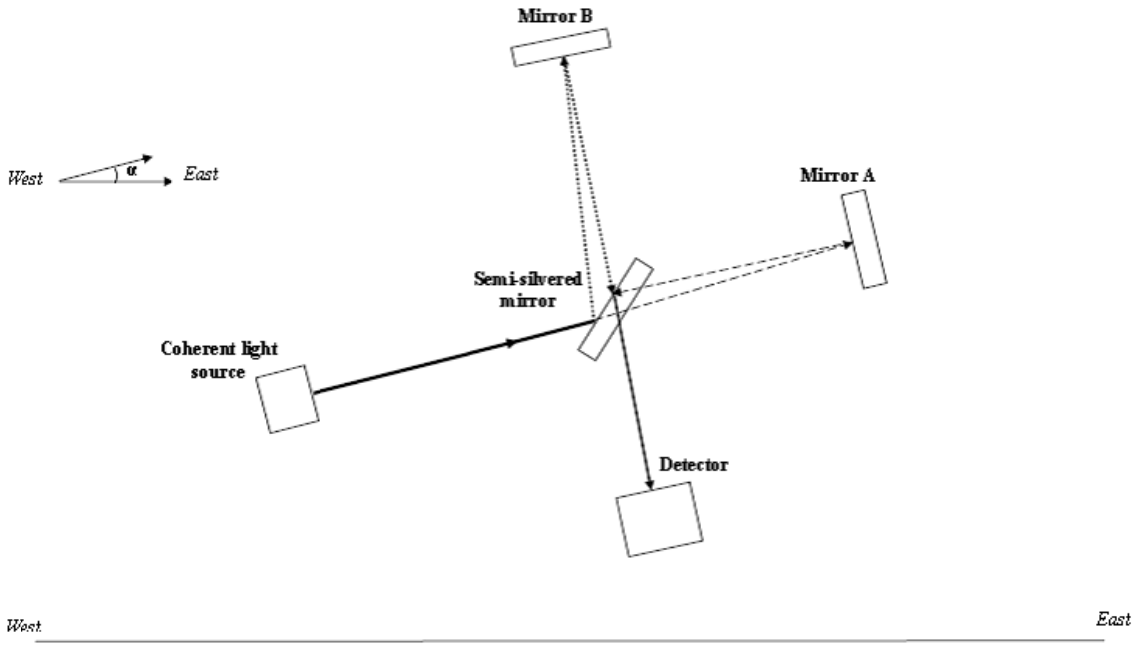
Mirror B
West
α
East
Mirror A
Semi-silvered mirror
Coherent light source
Detector
West
East

Figure 3.