A test to the constancy of the velocity of light with our solar system

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Abstract: This article is a detailed proposal of an astronomical test to be carried out within our solar system to try to detect the eventual addition of the speed of a celestial body to that of its emitted light -that reflected of the Sun in this case. This eventuality could be determined by observing the consequent variation in its apparent position that could produce the variation of the angle of aberration, a consequence, in turn, of the variation of the velocity of its emitted light. This area is chosen, despite having here celestial bodies with lower speeds than those of the stars, and their consequent lower sensitivity in the observations, to avoid the inconvenience of the enormous interstellar distances, which could disqualify the results of the test due to the possible intervention of the phenomenon of *extinction of the light wave* in that distances, as we will see in the Introduction of this article. To carry out the above, we need to have celestial bodies of different radial speeds with respect to our Earth, and in this area, we find them in the satellites of the other planets in the extreme positions of their orbits; and the observation of the possible different aberrations, in the variation of the apparent separations of the satellites from their planets in those positions. The proposal also includes the observation of the transit of a satellite across the front of its planet to detect the possible appearance of this phenomenon also in this different circumstance. It will also be possible to determine if it is the *relative speed* between the light source and the observer the one that effectively intervenes in this phenomenon of *light aberration*—planetary in this case—or if it is only that of the observer—that of our Earth—that produces it, as several authors maintain. To adequately illustrate the proposed test, and the order of magnitude of the intervening parameters, a specific example is developed with Jupiter and two of its satellites: IO and METIS. © *2023 Physics Essays Publication*. [http://dx.doi.org/10.4006/0836-1398-36.4.377]

Résumé: Cet article est une proposition détaillée d'un test astronomique à effectuer au sein de notre système solaire, pour tenter à détecter l'éventuelle adjonction de la vitesse d'un corps céleste à celle de sa lumière émis celui -celle réfléchie du le Soleil, dans ce cas. Cette éventualité pourrait être déterminée en observant la variation conséquente de sa position apparente qui pourrait produire la variation de l'angle d'aberration, elle-même conséquence de la variation de la vitesse de sa lumière émise. Ce région de l'espace est choisi -malgré qu'ici les corps célestes aient des vitesses bien inférieures à celles des étoiles, et leur moindre sensibilité résultante dans les observations- pour éviter l'inconvénient des les énormes distances interstellaires, qui pourraient disqualifier les résultats du test dans cet espace en raison de la possible intervention du phénomène d'*extinction de l'onde lumineuse* dans cet espace, comme nous le verrons dans l'Introduction de l'article. Pour réaliser ce qui précède, nous avons besoin d'avoir des corps célestes avec des vitesses radiales différentes par rapport à notre Terre, et dans ce domaine, nous les trouvons chez les satellites des autres planètes dans les positions extrêmes de leurs orbites, et l'observation de leurs éventuelles différentes aberrations, dans l'apparente variation de la séparation du satellite par rapport à la planète dans ces positions. La proposition comprend également l'observation du passage d'un satellite devant sa planète pour détecter l'éventuelle apparition de ce phénomène dans ce cas.Il sera également possible de déterminer si c'est la vitesse relative entre la source lumineuse et l'observateur celui qui intervient effectivement dans le phénomène d'aberration lumineuse –planétaire, dans ce cas ou si ce n'est que celui de l'observateur -celui de notre Terre- qui le produit, comme le prétendent divers auteurs. Pour bien illustrer le test proposé, et l'ordre de grandeur des paramètres intervenant, l'exemple précis est développé de Jupiter et deux de ses satellites: IO et METIS.

Key words: Velocity of Light; Special Theory of Relativity; Aberration of Light; Stellar Aberration; Planetary Aberration; Electronic Scattering of Light; Light Wave Extinction Length; Solar System; Satellites of Planets; Vector Composition of Light.

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I. INTRODUCTION

This work is the continuation of a previous one published in 2005: "An Astronomical Test for the Second Postulate of the Special Theory of Relativity,"[1] in which the systematic observation of a pair of stars conveniently selected is proposed with the aim of being able to detect possible variations of their apparent separations over time, caused by their also possible different *angles of aberration*.

As we know, the *Angle of Aberration* is the angle $\boldsymbol{\alpha}$ that a telescope must be tilted with respect to its theoretical direction in order to correctly focus on a star. This phenomenon, discovered by Bradley in 1727,[2] and called *Stellar Aberration*, was explained by him as the composition of the velocity of the light emitted by a star with that of the movement of our Earth.

If $\boldsymbol{v}$ is the tangential speed of the Earth, and $\boldsymbol{c}$ that of light, both, in the Bradley model and in the Einstein one,[3] which also explains this phenomenon, although with a different conception, for v perpendicular to c, its maximum value is produced, and the expression for the aberration α in this case is given by $\alpha = \text{arctg}\; v/c$, which for very small angles, such as the case at hand, is practically

$$\alpha = v/c. \tag{1}$$

Well, to carry out the aforementioned test, two stars that are visually close but with different radial velocities (r' and r'') are chosen, which, if added to those of the light emitted by them, would give us two stars emitting light with different speeds, ($c' = c + r'$ and $c'' = c + r''$), which, in Eq. (1), would be observed with different aberrations, α' and α'', then varying their apparent separation $\boldsymbol{\delta}$ over the course of, for example, a year, in which the aberration varies for all celestial bodies, according to their relative positions with respect to our Earth, or, to say, their locations on our celestial sphere.

In said publication, I prove that the maximum variation of the apparent separation between them—or difference between maximum and minimum separation—would be given by

$$\Delta_{\max}\delta = \delta_{\max} - \delta_{\min} = 2(\alpha' - \alpha''). \tag{2}$$

I also develop there an example with two stars with supposed radial velocities $r' = -60$ km/s (approach) and $r'' = +300$ km/s (distancing). Operating with these values, totally plausible, and taking for $c = 300\,000$ km/s, and for $v = 30$ km/s, I arrive at $\Delta_{\max}\delta = 0.05''$ (arc sec), a value that, although very small, can be perfectly measured by current astrometry.

In its chapter **Stellar Aberration,** we can find the development of the Bradley's model of this phenomenon, its vector analysis, and how to arrive at the formulas used in the mentioned example. For a better understanding of the present proposal, I recommend taking a look at it.

To date I do not know that this test has been carried out, which, as we will see, would have questionable results. In the aforementioned publication of its proposal, I highlight the works of Professor J. G. Fox published in the 1960s in the *American Journal of Physics*[4–6] in which he highlights the phenomenon of *Electronic Dispersion of Light*[7] and the *Light Wave Extinction Length Theorem*,[8] and how, according to him, these phenomena would render previous arguments worthless and the results of many experiments that supported the ***constancy of the velocity of light*** (CVL). The reason is that due to these phenomena, light would be re-emitted with its characteristic speed $\boldsymbol{c}$ when passing through—or being reflected by—a dielectric, regardless of the speed that the wave could have when it hits this medium. And so the air would also act, so that the earth's atmosphere would be a "matching filter" for the light rays from the firmament.

Aware of this phenomenon (which would also invalidate my previous tests proposals,[b]) always on the subject of the CVL) by reading the works of Fox, long after their publications, and stimulated by the considerations that he makes in them about the need for modern Physics to resolve this crucial issue, and his appeal to the imagination of researchers to face new experiments that *shed light* on it, is that I developed this idea of testing the possible different *light aberrations* in stars of different radial velocities.

This is how my quoted publication[1] was born. Once again, I recommend a look at it, but this time at its **Introduction**, to see the reasons I expose there -and that I still maintain—to consider the CVL an intrinsically illogical hypothesis; how, despite it was also so considered by many scientists since its enunciation, was being accepted due to the concordance of the experimental results with those predicted by the application of the RT formulas (there I also expose the guidelines of a theory, of logical bases—which I call "of mobile fields"—with whose development one could arrive at similar formulas); that CVL has not yet been conclusively proven, and to endorse this statement I detail the experiments and natural phenomena that were taken by Einstein to support his basic hypothesis of RT, and how they can be explained in other more logical ways. It is also worth noting that there are other logical arguments against this postulated constancy, and that it is still being questioned today in publications.[9,10]

Also, there I expose my idea that the "matching" of the atmosphere would not affect the test, considering that the composition of velocities that would give rise to the *aberration* (Bradley's model, on which both the aforementioned test and the one I am proposing in this publication are based) would occur, precisely, in its first layers, where the *extinction of the light wave* would also take place.

What I did not notice at the time is the estimation that Fox makes, applying the formulas of this *theorem of extinction length* for interstellar space (considers in it the existence of one hydrogen atom per cm^3), and which results on the order of one light year.[5,6] We then have that, if this estimate is valid, it would also disqualify a positive result—the CVL verification—of the proposed test, since there is no star in our celestial sphere at a distance less than one light year, quite the opposite.

[b]These proposals are not published. They were interventions of mine in "The Rolex Awards for Enterprise" in the years 1977 and 1981. In the first, light rays of possible different velocities passed through a sheet of glass, and in the second, they suffered multiple reflections in mirrors at high speed.

We then supposedly find ourselves with the fact that the light coming from the stars, although it could initially have their speed incorporated, the enormous distance that separates us from them, in a space that is not totally empty, would also act as this filter, making it always reach us with its characteristic speed *c*.

Other conclusions that this fact would invalidate are those derived from observations of visual binary stars, with which it was expected to obtain significant aberrations, which, when not occurring, gave rise to indications of *lack of symmetry in the stellar aberration*, and even taken as **evidence of the non-compliance with the Special Theory of Relativity** (STR), because their authors consider that in this theory, in the stellar aberration formula, *v is the relative speed* between the light source and the observer, regardless of which of them is considered as the one that moves.[11–18]

The test that I propose in my publication "A Test in the Outer Space for the Constancy of the Velocity of Light"[19] would also be invalidated, a setup capable of separating light beams of eventual different speeds (those of the previous test, for example) by means of a rotating mirror of the type used by Foucault in his measurement of the speed of light. This test, of great sensitivity, is indicated to be carried out only in the case of ambiguity in the results of the previous one, given its great difficulty in carrying it out, due to the fact that it can only be carried out outside our atmosphere, to avoid re-emission light of it. This great difficulty is justified by its great sensitivity. Well, this eventual resource is, then, also valid for the present proposal.

Although I do not know the degree of verification of these theories, given the possibility that they are true, and make the possible positive results (constancy of *c*) of possible test performances worthless, if we want to maintain their conception, as it is my case, we will have to test closer celestial bodies, such as those in our solar system. Here, we have planets and their satellites, and the occasional comet that from time to time crosses our skies.

Now, we do not have the distances that could invalidate the results of the observations, but the speeds of the objects to be observed are much lower, and, consequently, their sensitivity, which will require much greater precision.

II. THE TEST WITH OUR SOLAR SYSTEM

Maintaining the conception of the test in this area supposes determining the possible different aberrations of celestial bodies with different radial velocities, which implies recording their apparent relative positions over time. We can obtain this, as we will see later, with the satellites of the other planets, which will also offer us other possibilities to test. Also, due to the fact that the planets are in continuous movement in their known orbits, we will test if it is the ***relative speed*** between the observed planet and our Earth the one that **effectively intervenes** in this phenomenon of *Light Aberration*.

A. The planetary aberration

When Bradley[2] explains the phenomenon of stellar aberration as the composition of the speed of the light emitted by a star with that of the movement of our Earth, he is assuming the *emissive* character of light, in a scenario of fixed stars in the celestial sphere and a mobile observer: the astronomer on our planet. Hence, the natural comparison of many textbook authors with the pedestrian walking in the rain, umbrella in hand, on a windless day with still clouds; and how, because he is walking, he will have to tilt the umbrella forward to avoid getting wet. And so an astronomer on our Earth has to do with his telescope to be able to correctly focus on a star.

This inclination of the telescope is th*e angle of stellar aberration*, which varies according to the time of year of its observation, but whose maximum value is the same for all: The *aberration constant*.

But in our solar system, the scenario is different: Our pedestrian is walking under a rain of clouds that, depending on where he walks, move with different speeds, as well as different directions of their movements. He will then have to tilt his umbrella according to his movement and that of the clouds. These two movements will result in a certain inclination for a certain moment.

Well then: Following this model,—which is the one I adopted in my previous proposal,[1] and which I do support in this one- in the observations of the other planets we could have two superimposed aberrations: The one produced by our movement (v_E): α_E, and that of the movement of the planet observed (v_P): α_P.

The resultant of these two aberrations would be equal to α_R, which would produce $v_{R,}$ the vector sum of both velocities. This resulting speed, obviously, will vary continuously with the positioning of the planets in their orbits, and will go from smaller values, when both are on the same side with respect to the Sun—and the sense of the Earth movement coincides with that of the other planet—to higher values, when they have opposite directions (opposite sides).

These relative speeds are ultimately different cases of the *relative velocity between the light source and the observer*, and, if the observed aberrations coincide with the calculated ones for each case, we could have here the determination that this is the velocity that intervenes in the phenomenon of aberration—planetary in this case. In the present test, we would have this determination through the apparent separations of the analyzed satellite with respect to its planet, in its extreme positions, produced with each relative speed, as we will see later.

A positive result in this area could be extended to all the celestial bodies and would lead us to understand that if with the visual double stars were not found, it was, surely, due to the phenomenon of the *electronic dispersion of light* already mentioned in the **Introduction**, and that it would confirm the calculation of Professor Fox[6] on the *length of the extinction of the light wave*,[8] which for interstellar space would be of the order of a light year, making eventual variation in the speed of light emitted by them disappear at these distances.

Likewise, with this confirmation, it could be calculated the real positions of the planets, and thus determine their theoretical orbits, with the corrections due not only to our movement but also to those of the planets.

There are several authors, however (Ref. 17, for instance), who consider th*e Aberration—Stellar or*

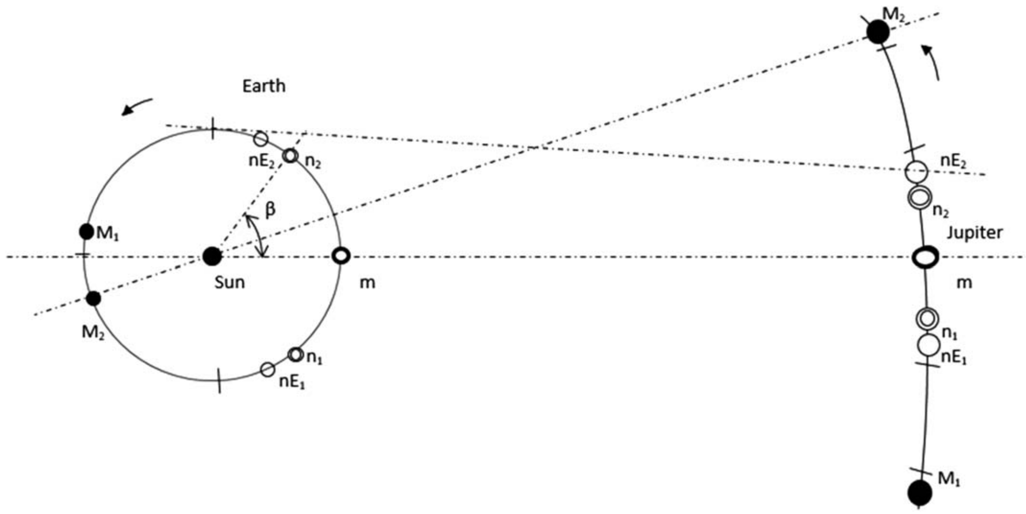

FIG. 1. Earth and Jupiter at key points in their orbits.

Planetary—as a phenomenon due exclusively to the movement of our Earth; and that the planetary one is produced by the so-called *light time:* The difference between the real and apparent positions of a planet is the distance traveled by the planet in the time it takes for its light to reach us. In my opinion, this is a true fact, but valid not only for the planets but for the entire map of the celestial sphere: We see stars so distant that perhaps they no longer exist or that they are actually very far from where we are seeing them. But here we want to establish with this proposal whether the movement of the planets, and that of their satellites, adds to that of their emitted light, affecting its direction, thus giving rise to *aberration*: The additional tilt of the telescope to be able to align with this modified path of its light.

Let us also note, on the other hand, that Einstein, in his first publication of 1905 on STR,[3] in the chapter referring to the *Doppler Effect and Aberration*, does not consider the possible movement of the light source, "infinitely distant from an observer" (sic), which is the one that moves with respect to the coordinate system that contains said light source, whose line of sight forms a certain angle with these coordinates. (We see that, ultimately, in this scenario there is no place for *relative speed*, since it makes no geometric sense to speak of relative motion between one point and another located at infinity). And he calculates the aberration produced in the observation of this angle with the application of his famous *relativistic—or of Lorentz-transformations*, not giving to this phenomenon any tangible physical explanation.

Russo,[20] in his publication on this phenomenon, makes a detailed analysis of this model and its physical inconsistency.

My position is that Relativity does not consider—as we have just seen, and paradoxically—the *relative* speed between the light source and the observer as the one involved in the phenomenon of Aberration, but only that of the latter. In fact, it does not address this phenomenon, as neither Bradley did, with the planets. So, a positive result of the test on this issue would not mean an endorsement to this theory, as expected with the sought *symmetry of the stellar aberration* with double stars, but rather the opposite**:** If the relative speed between the Earth and the other planet were the one that actually intervenes in the observed aberration, this would imply that the movement of the other planet also produces this phenomenon, which would show us the emissive nature of light, contrary to the constancy of its speed, fundamental hypothesis of the STR.

B. The development of the test

The astronomical observatory that carried out the test surely has tools to know the relative velocity between the observed planet and our Earth on any observation date. Here will been presented an example to see the magnitudes of the parameters to be observed and calculated in which we will calculate their relative speeds only at *key points*, in which these speeds are simple to calculate, without needing to go to the resolution of trigonometric equations.

It is done with the specific example showed in Fig. 1 that represents the paths of the Earth and Jupiter in their orbits in a period of just over 13 months, in which all the possible configurations between the two planets are given, and which are repeated from this one. Have been marked on these orbits with small li perpendicular to them their 3-month paths, and tried to maintain adequate proportions, taking into account that the orbital radius of Jupiter is 5.2 times that of the Earth, and its orbital period, of almost 12 times ours (11.86, to be exact). It has been indicated, then, here, the positions of the planets in these *key points,* and, next, how we determine them:

Key point 'm' (thick circles): Of the **minimum separation** between them.

Key point 'M' (full circles): Of **maximum separation**, and diametrically opposite positions with respect to the Sun: Knowing the date of the previous one, and taking into account the ratio of the values of the orbital periods of both planets, that for our example we can take it as 12, we determine this point by solving the equation

$$\beta - 180^\circ = \beta/12, \tag{3}$$

which, resolved, gives for β (angle distended by the Earth's radius from its position in m to this point): $\beta = 196.36^\circ$. In other words, $\beta = 196.36^\circ \times (365\,\text{days}/360^\circ) \approx 199$ days from point m.

At these two points, the tangential velocities of both planets are perpendicular to their line of sight, consequently producing in them the maximum aberrations in those opposite sectors of their orbits: $\alpha_m = (v_E - v_J)/c$ and $\alpha_M = (v_E + v_J)/c$, also resulting in an easy calculation their relative velocities in them.

Now, this test consists of comparing the calculated possible aberrations with those observed. And, to be able to measure these last ones, we will have to compare the observed location of the satellite in these points with that observed from one where we know that there is no aberration. But the aberration, as we saw above, could be caused by two different speeds: (a) the relative one between the two planets, or (b) that of the movement of our Earth only. And this is also something to determine with our test.

We will have to locate, then, for this comparison, two other key points:

Key point ‘n’ (fine double stroke circles): **Null aberration** with **positive intervention of relative velocity**: If the movement of both planets produces aberration, for it to be null, the relative speed between them has to be zero; and this can happen only when the projections of the vectors of both tangential velocities, v_E and v_J, coincide on the perpendicular to Jupiter’s line of sight. We can find it graphically or going, so we will do here, to trigonometry, solving the simplified equation (for considering in it the aforementioned visual as parallel to the Sun–Earth line of point ‘m’, which is only approximate):

$$v_E \cos\beta = v_J \cos(\beta/12). \tag{4}$$

Solving this equation, we will have for β an approximate value of 57°, which is equivalent to $57^\circ \times (365\,\text{days}/360^\circ) \approx 58$ days from the date of point ‘*m*’.

Key point ‘n’ (fine single stroke circles): **Null aberration** with the **only intervention of the Earth movement:** The movement of our Earth will not produce aberration when its direction coincides with the line of sight of the other planet. Here, we will find it graphically: The tangent to the Earth’s orbit at this point must pass through Jupiter. The result will be approximate, but it will serve for our illustrative purposes.

The location of these three points, ‘M’, ‘n’, and ‘nE’, in the calendar of observations, and in the orbits of the two planets, begins with the date of point ‘m,’ and can be done forward or backward from this point (since the Sun—‘m’ line is the axis of symmetry of the positions of Earth and Jupiter), by adding or subtracting from that date the days just determined for each of these points. In Fig. 1, it is marked the two options, which in practice may be useful, by expanding the calendar of observations.

Let us see what this calendar would look like in the event that point ‘m’ fell on us on December 31, 2024:

‘M_1’: 12.31.2024 – 199 days = 06.15.2024,

‘nE_1’ (graphically found): ≈ 10.07.2024,

‘n_1’: 12.31.2024 – 58 days = 11.03.2024,

‘m’: ″ 12. 31.2024,

‘n_2’: ″ + 58 days = 02.27.2025,

‘nE_2’ (graphically found): ≈ 03.26.2025,

‘M_2’: 12.31.2024 + 199 days = 07.18.2025.

Very well, we have determined a calendar with convenient dates for observing the possible separations between the planet and the chosen satellite. We will then calculate the values of these possible aberrations to compare them with those observed. To do this, let us first analyze this possible phenomenon with the satellites.

C. The satellite aberration

The satellites of the other planets, in their orbital movements, take positions in which their tangential velocities are radial to our observation, approaching and receding, and also parallel to our displacement. Here, then, we have celestial objects with different radial velocities that, if incorporated into those of their light, could produce different aberrations, and that, not being at the distorting distances of the stars, we could test comparatively, as I proposed with those in my 2005 post.[1] And although their velocities are much lower than those that we can find in stars, and, consequently, the aberrations that they could produce, we will see with the example to be developed later that current Astrometry has ultrasensitive observation instruments capable of measuring them, such as is the case, for instance, of the ESA’s Gaia satellite telescope, with a resolution of 20 μs, that is: 0.000 020″.

Let us now see in Fig. 2, the parameters to be measured in the performance of the test.

It is represented in this figure a planet and one of its satellites, with tangential speed s, in three different positions: Let us agree that in the one on the left the satellite is approaching us; therefore, in the one on the right it moves away, and in the one in the center it travels from left to right.

We will then have three different instances of possible aberration for this satellite: The two of its extreme positions, and the one of the center. We will first analyze the extreme ones: The one on the left ($\alpha_l = v_R/c_l$) with less aberration than that of the planet ($\alpha_P = v_R/c$), since the speed of its light

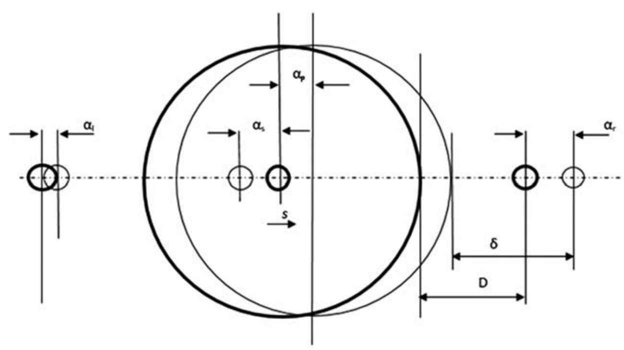

FIG. 2. Planet with one of its satellites in three different positions of its orbit.

could be greater than the one of this ($c_1 = c + s$); the one on the right, on the contrary, as the speed of its light would be less ($c_r = c - s$), the consequent aberration would be greater ($\alpha_r = v_R/c_r$).

For these two cases, we will measure their maximum apparent separations 'δ' from the planet on the dates calculated for points '*m*', '*M*', '*n*', and '*nE*', explained above and indicated in Fig. 1.

The variation of these maximum apparent separations δ with the different observation dates would show us the non-constancy of the velocity of light coming from the satellite; and the values of these variations ($\Delta\delta$), and their comparisons with the calculated possible aberrations, would indicate us which is the intervening speed in each point, allowing us to better understand the mechanism of the *Aberration of Light*, in general.

In this figure, the size of the satellite and the variation of these separations have been exaggerated to more clearly show the parameters involved. Let us note the expected direction of these shifts according to the point of the Earth's orbit from where they are observed: For the direction of the planets movement indicated in Fig. 1, the largest aberration in 'M' and that of the entire sector, contrary to of Jupiter with respect to the Sun, it will be to the right, as we show in the figure, since this is the movement of the Earth and the opposite of the movement of Jupiter, resulting for 'm' and the surroundings of that point—up to 'n', of zero total aberration—the aberration to the left, since that is the direction of the movement of the Earth, which produces an aberration greater than the opposite that Jupiter would produce in that around.

On the other hand, given that the aberration of the satellite in the position on the left would be less than that of the planet, and that of this one, less than that on the right ($\alpha_l < \alpha_P < \alpha_r$), shifts to the right would produce greater apparent separation of the satellite with respect to the planet in its extreme positions, and, on the contrary, apparent approach in the shifts to the left. So that in the observations from the sector of 'M', we would have apparent separations, and in those of the sector of 'm', approaches. This fact, by itself, as we saw above, would indicate the **non-constancy of *c***, and would allow us to simplify the performance of the test with the sole observation of the extreme positions of the satellite in these sectors. Although this would be valid, it will be developed the example to show the order of magnitude of the expected aberrations, as well as the incidence in these of the different relative velocities of possible intervention.

Let us also highlight that these separations or approaches would be practically of the same magnitude on both sides of the planet, due to the fact that in the aberration formula, the factor that makes its value vary is the same, the tangential speed of the satellite, *s*, adding to that of light, *c*, in the position on the left, not intervening in that of the planet, and subtracting from it in the one on the right, as we clearly see by making explicit the relationship of the aberrations expressed above: $v_R/c + s < v_R/c < v_R/c - s$. In the example developed below, we see this fact numerically that will allow us to reduce the observations to only one side of the planet.

For the central position of the satellite, the only aberration to observe is the possible one produced by its movement with respect to the planet, since the one produced by the relative between the two planets would affect the satellite and the planet equally. The direction of the expected aberration here is obviously the opposite of that of the satellite's motion, and so has been indicated in the figure.

This possible aberration would be of an order of magnitude much greater than those of the extreme positions, since the tangential speed of the satellite, s, would intervene directly in its production ($\alpha_s = s/c$), resulting this observation of much greater sensitivity than the previous ones. This fact, together with the one that its value does not depend on the observation date (although it will be convenient to do it from point 'm' due to its greater proximity to the planet, and its frontal observation, and consequent sensitivity), and to the fact that **a positive result here would directly evidence the emissive nature of light**, since it would be only the mobile element of an observed set which modifies the angle of its visual, make this observation perhaps the most interesting of this proposal. But, on the other hand, its feasibility is subject to being able to select a satellite whose brightness can be observed above the reflected light of the planet. A clipped shadow on it would not work, since we are testing the possible emissivity of its light.

III. ILLUSTRATIVE EXAMPLE OF THE TEST

Although more than 200 natural satellites are known in our solar system, I estimate that there will be only a few that meet the conditions of observability to carry out this test with them. But, to get an idea of the expected values of the different aberrations to be tested, I chose two from Jupiter, the planet that had been already taken as an example in determining the *key points*: METIS and IO, because I considered them good "candidates" for this purpose: The first, because it is the closest to the planet and has the highest tangential speed, and the second, simply because it was the one conveniently chosen by Römer for his famous determination of the speed of light.

With METIS we will calculate the possible aberrations in their extreme positions for each of the relative speeds of possible intervention in this phenomenon, at the determined *key points*. And with IO, only the one that would produce its transit through the "face" of the planet.

Let us see, then, the values considered for the calculation of all the parameters involved in these algorithms, and the respective results:

Considered Values:

- Speed of light *c*: 300 000 km/s
- Earth's Orbital Radius EOR: 150 000 000 km (1 AU)
- Earth's Orbital Period EOP: 365.25 days (1 year)
- Jupiter's Orbital Radius JOR: 5.2 AU
- Jupiter's Orbital Period JOP: 11.86 years
- Metis Orbital Radius MOR: 128 000 km
- Metis Orbital Period MOP: 0.295 days
- IO's Orbital Radius IOR: 421 800 km
- IO's Orbital Period IOP: 1.7 days

Calculated values of the possible intervening speeds:

- Tangential velocity of Earth: $v_E = 2\pi$EOR/EOP $= (6.28 \times 150 \times 10^6$ km)/365.25 days $= 29.9$ km/s
- Tangential velocity of Jupiter: $v_J = 2\pi$JOR/JOP $=$ $= (6.28 \times 5.2 \times 150 \times 10^6$ km)/(11.86 $\times$ 365.25 days) $=$ $= 13.1$ km/s
- Tangential velocity of Metis: $s_M = 2\pi$MOR/MOP $= (6.28 \times 128\,000$ km)/0.295 days $=$ $= 31.5$ km/s
- Tangential velocity of IO: $s_I = 2\pi$IOR/IOP $=$ (6.28 $\times$ 421.800 km)/1.7 days $= 18.0$ km/s
- Relative Velocity Earth/Jupiter in Position 'm': $v_m = v_E - v_J = 29.9$ km/s $- 13.1$ km/s $=$ $= 16.8$ km/s
- Relative Velocity Earth/Jupiter in Position 'M': $v_M = v_E + v_J = 29.9$ km/s $+ 13.1$ km/s $=$ $= 43.0$ km/s

Before going to the calculation of the possible observable aberrations from each of the key points, we will make the numerical demonstration of what was said above on the practical equality of the apparent displacements of the satellite on either side of the planet. To do this, we will calculate these separations for the case of maximum possible aberrations: Those of point '*M*':

- Satellite on the left: $\alpha_{lM} = v_M/(c+s) = [43.0$ km/s/(300 000 + 31.5) km/s] $\times (360°/2\pi) =$ $= 29.5766''$
- Planet: $\alpha_{PM} = v_M/c = (43.0$ km/s/300 000 km/s) $\times$ $(360°/2\pi) = 29.5796''$
- Satellite on the right: $\alpha_{rM} = v_M/(c-s) = [43.0$ km/s/(300 000 – 31.5) km/s] $\times (360°/2\pi) =$ $=29.5827''$

From here, it results:

- Difference Planet/Satellite aberrations on the left: $29.5796'' - 29.5766'' = 0.0030''$
- Difference Planet/Satellite aberrations on the right: $29.5827'' - 29.5796'' = 0.0031''$

Thus, we have verified what was said above. This fact simplifies the calculations and the observations, since it will suffice to do it with only one of the extreme positions. We will do it here with the one on the right.

Let us then calculate the possible observable aberrations from each of the determined key points, both in the event that the movement of both planets is involved in this phenomenon ('M', 'm', and 'n'), and in the event that only the one of our Earth is involved ('ME', 'mE', and 'nE').

Point 'M':

- Planet Aberration: $\alpha_{PM} = v_M/c = (43.0$ km/s/300 000 km/s) $\times (360°/2\pi) = 29.5796''$
- Satellite Aberration: $\alpha_{rM} = v_M/(c-s) = [43.0$ km/s/(300 000 – 31.5) km/s] $\times (360°/2\pi) =$ $= 29.5827''$

Point 'ME':

- Planet Aberration: $\alpha_{PME} = v_{ME}/c = (29.9$ km/s/300 000 km/s) $\times (360°/2\pi) = 20.5682''$
- Satellite Aberration: $\alpha_{rME} = v_{ME}/(c-s) = [29.9$ km/s/(300 000–31.5) km/s] $\times (360°/2\pi) =$ $= 20.5703''$

Point 'm':

- Planet Aberration: $\alpha_{Pm} = v_m/c = (16.8$ km/s/300 000 km/s) $\times (360°/2\pi) = 11.5567''$
- Satellite Aberration: $\alpha_{rm} = v_m/(c-s) = [16.8$ km/s/(300 000–31.5) km/s] $\times (360°/2\pi) =$ $= 11.5579''$

Point 'mE':

- Planet Aberration: $\alpha_{PmE} = v_E/c = (29.9$ km/s/300 000 km/s) $\times (360°/2\pi) = 20.5682''$
- Satellite Aberration: $\alpha_{rmE} = v_E/(c-s) = [29.9$ km/s/(300 000–31.5) km/s] $\times (360°/2\pi) =$ $=20.5703''$

Point 'n': The aberration here is null, since null is the relative speed between the Earth and the other planet. Or, what is the same, the aberrations produced by each of the planets are compensated here, giving a null result.

Point 'nE': And here the aberration will be null because the one produced by the Earth is null, which we are assuming that is the only planet that produces it.

We have calculated the aberrations that could be observed from the chosen key points. Let us now see how we will measure them in the respective observations, and thus be able to compare the results obtained, in carrying out the test:

If we call *D* the real visual separation (without any intervening aberration) of the satellite with respect to the planet, and α_P and α_r the aberrations of the planet and the satellite in its position to the right, respectively, we will have that the apparent visual separation will be $\delta = D + \alpha_r - \alpha_P$ or $\delta = D - \alpha_r + \alpha_P$ depending on whether the resulting aberration is to the right or to the left.

Let us see, then, what would be these apparent separations in the key points, according to the intervention or not of the movement of the two planets in the phenomenon of aberration:

- Point 'M': $\delta_M = D + \alpha_{rM} - \alpha_{PM} = D + 29.5827'' - 29.5796'' = D + 0.0031''$
- Point 'ME': $\delta_{ME} = D + \alpha_{rME} - \alpha_{PME} = D + 20.5703'' - 20.5682'' = D + 0.0021''$
- Point 'm': $\delta_m = D - \alpha_{rm} + \alpha_{Pm} = D - 11.5579'' + 11.5567'' = D - 0.0012''$
- Point 'mE': $\delta_{mE} = D - \alpha_{rmE} + \alpha_{PmE} = D - 20.5703'' + 20.5682'' = D - 0.0021''$
- Point 'n': $\delta_n = D$
- Point 'nE': $\delta_{nE} = D$

The best adjustment of the values of the observed separations to those of the calculated ones, for each one of the possible aberrations, in the key points 'M' and 'm', will indicate which of the velocities is the one that actually intervenes in this phenomenon: that of the Earth only or the relative one between both planets. Let us see:

If both planets are involved in the aberration:

- Point 'M': $\delta_M = D + 0.0031'' \rightarrow$ $\mathbf{D = \delta_M - 0.0031'' = \delta_n}$**?** (Compare with the observation from point n).

- Point ‘m’: $\delta_{\rm m} = D - 0.0012''$ $\rightarrow$ $\mathbf{D = \delta_m + 0.0012''}$ $\mathbf{= \delta_n}$**?** (Idem, idem)

If only the Earth intervenes in the aberration:

- Point ‘ME’: $\delta_{\rm ME} = D + 0.0021''$ $\rightarrow$ $\mathbf{D = \delta_{ME} - 0.0021''}$ $\mathbf{= \delta_{nE}}$**?** (Compare with the observation from point ‘nE’).
- Point ‘mE’: $\delta_{\rm mE}$=D – 0.0021″ $\rightarrow$ $\mathbf{D = \delta_{mE} + 0.0021''}$ $\mathbf{= \delta_{nE}}$**?** (Idem, idem)

IO aberration:

$$\alpha_I = s_I/c = (18.0\,\text{km/s}/300\,000\,\text{km/S}) \times (360°/2\pi) = 12.38''$$

Here, we have, as we said above, the most sensitive and, perhaps, conclusive observation of this test. It will only be a matter of properly determining the instant of the satellite’s position at the center of the planet’s apparent disk (by averaging the times at the extreme positions, I guess), and comparing the observed position at that instant with the corresponding calculated one. Obviously, the eventual difference of these positions would measure the observed aberration.

IV. CONCLUSIONS

Carrying out this test could elucidate such a crucial question for current Physics as the *Constancy of the Velocity of Light*, which, despite being the basic hypothesis of the *Theory of Relativity*, still lacks—in my opinion, and that of many—of a direct and conclusive verification.

And, if its non-constancy turned out evident with it here, with our solar system, it would be recommended the realization of my proposal of 2005,[1] much simpler than this, with suitably chosen stars. And, if we had an opposite result in that case—the affirmation of its constancy—this different result would lead us to accept the calculation that Fox makes for the interstellar space[5,6] of the *Extinction Length of the Light Wave* with the application of the *Ewald and Oseen* Theorem[8] formulas, that for a distance greater than one light year in that medium would wipe out any trace of the eventual variation in the speed of light; and, of course, the theories on which these calculations are based. And, for the same reason, these different results would also clear up the doubts and controversies about the *Lack of Symmetry in Stellar Aberration*, raised with the observations of visual binary stars.[11–18] (Faced with this possibility, I see the convenience of carrying out both tests simultaneously, alternating the observations of the selected planets with the one of the selected stars, throughout the period of one year conveniently chosen for both tests).

And, above all this, a thorough revision of all modern Physics would be inevitable, a consequence of the end of a century of Relativity. On the contrary, a confirmatory result of this constancy would further affirm the validity of this famous but still questioned theory.

I present these last concepts in order to encourage astronomers—whom I apologize for daring to address their subjects—to the realization of this proposal, aware as I am of how complicated it will be, due to the almost insignificance of the parameters to be measured, with measurements that will surely many times be taken as observation errors, with their consequent repetition. Thus, I echo, once again, the words of Prof. Fox in the Conclusion of his 1962 publication:[21]

> “Nevertheless, if one balances the overwhelming odds against such an experiment yielding anything new, against the overwhelming importance of the point to be tested, he may conclude that the experiment should be performed.”

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