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*GRAVITATIONAL DEFLECTION OF LIGHT
IN A PLATONIC QUADRIDIMENSIONAL SPACE*

Alain Jégat

Abstract

The gravitational deflection of light has been measured by many experiments, in accordance with the expectations of the theory of general relativity.

In articles hal-01756323 and hal-01970150, the research carried out in the quadridimensional Platonic model framework has successively demonstrated the equivalence of the second quantified declination postulate and the conservation of the absolute angular momentum; and then the link between the conservation of energy and quantified variations of absolute time.

These effects, both related to the De Broglie mass waves, can be conjugated and lead precisely, in a quantified way, to these relativistic experimental results.

*DÉFLEXION GRAVITATIONNELLE DE LA LUMIÈRE
DANS UN ESPACE QUADRIDIMENSIONNEL PLATONICIEN*

Résumé

La déflexion gravitationnelle de la lumière a été mesurée par de nombreuses expériences, conformément aux attentes de la théorie de la relativité générale.

Dans les articles hal-01739986 et hal-01949616, les recherches menées dans le cadre du modèle quadridimensionnel platonicien ont mis en évidence, successivement, l'équivalence du second postulat de déclinaison quantifiée et de la conservation du moment cinétique ; puis le lien entre la conservation de l'énergie et les variations quantifiées du temps absolu.

Ces effets, tous deux liés à l'onde de phase de De Broglie, peuvent être conjugués et conduisent précisément, de façon quantifiée, à ces résultats expérimentaux relativistes.

Introductory

According to the theory of general relativity, light does not propagate in a straight line in a gravitational field: it undergoes a deflection when passing near massive bodies.

Thus, while passing near the Sun, the expected deflection can reach 1.75 arc second (in Newtonian mechanics, the corresponding expected deflection is equal to half of this value).

For example, these results can be tested by observing stars close to the Sun during an eclipse. British expeditions to Sobral, Brazil and to the island of Principe in West Africa, led by Frank Watson Dyson and Arthur Stanley Eddington during the eclipse of May 29, 1919, were thus able to confirm the results predicted by the theory of general relativity.

Many subsequent observations of the deflection of light confirmed Eddington's results with significantly better accuracy (the accuracy of these early results was questioned in the 1980s by science philosophers John Earman and Clark Glymour, claiming that the selection of the data collected was biased).

Among others, in 1937 the Swiss astronomer Fritz Zwicky predicted that galaxies can cause gravitational effects on the light of the sources they obscure: these effects of "gravitational lenses" were regularly confirmed in recent decades, after the discovery of the first multiple image quasar in 1979, the first gravitational arc in 1987 and the observation of Einstein rings (the Einstein rings are a special case where the deformation in the form of a ring or an arc of a light source passing through a gravitational lens is formed by an extremely massive celestial body).

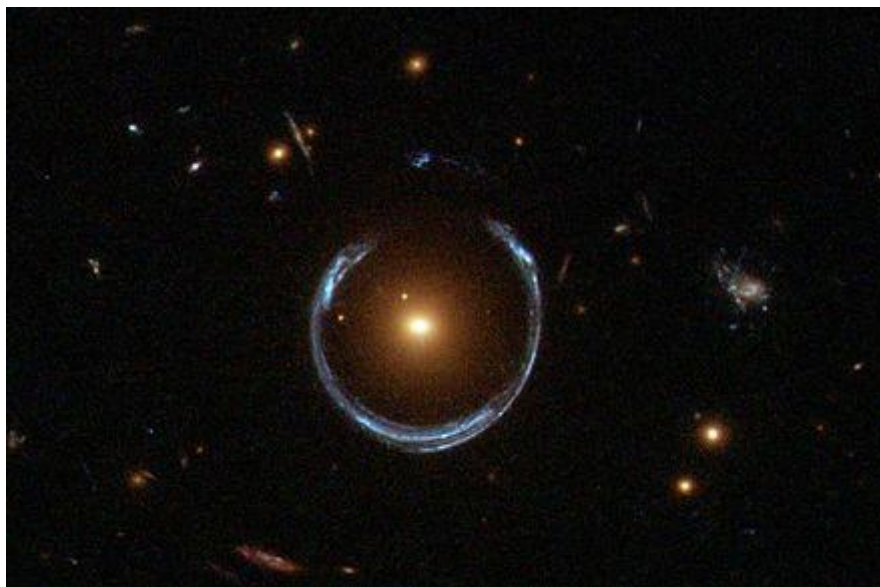


Fig. 1 - Near-perfect Einstein ring detected by the Hubble space telescope. The central object is the LRG 3-75 intermediate galaxy. The alignment between the two galaxies is here such that the image of the background galaxy outlines the shape of a circle. (NASA / HST)



Fig. 2 - This image, taken with the Hubble Nasa-ESA space telescope, shows a gigantic cluster of galaxies located about 4.6 billion light years away. Along its borders, four luminous arcs are visible. These are copies of the same distant galaxy known as the Sunburst Arc. The Sunburst Arc galaxy is nearly 11 billion light years away. Three arcs are visible at the top right of the image, the fourth at the bottom left. The latter is partially masked by a bright star in the foreground, located in the Milky Way. © ESA, Hubble, Nasa, Rivera-Thorsen.

*The purpose of this study is to show that **the framework of the Platonic quadridimensional space allows these results to be found in a quantified way,** by relating them to the De Broglie mass waves generated by massive bodies.*

1. The geometrical framework

This modeling is based on the Platonic space outlined in the following articles:

« UN MODÈLE PLATONICIEN (EUCLIDIEN-PROJECTIF) POUR LA THÉORIE DE LA RELATIVITÉ RESTREINTE » (pré-publication hal-01081576, version 1).

« A PLATONIC (EUCLIDEAN-PROJECTIVE) MODEL FOR THE SPECIAL THEORY OF RELATIVITY » (pre-publication hal-01165196, version 1).

$(O, \vec{i}, \vec{j}, \vec{k}, \vec{h})$ is a frame for the quadridimensional Euclidean space whose axes are denoted $(OX), (OY), (OZ), (Ow)$; the direction of the projection is that of the vector \vec{h} .

Following the hal-01207447 and hal-01213447 articles, the notion of relativistic mass of a particle is described as a result of its interaction with a stratification of the quadridimensional Platonic space by a sequence of hyperplanes $H^{(n)}$ which are orthogonal to the direction of the projection \vec{h} , regularly spaced by a distance $\Delta w_0 > 0$.

This distance Δw_0 is equal to the **Compton wavelength** of the particle in question (for example,

for an electron, $\Delta w_e = \frac{h}{m_e c} \approx 2,426.10^{-12}$, where m_e denotes the rest mass of the electron).

These concepts are detailed in the Hal articles below:

hal-01165196, v1 : A Platonic (Euclidean-projective) model for the special theory of relativity.

hal-01207447, v1 : Towards a modeling of De Broglie waves in a Platonic quadridimensional space.

hal-01213447, v1 : An idea of the mass of a particle in a Platonic quadridimensional space.

hal-01247385, v1 : A modeling of Michelson-Morley interferometer in a Platonic quadridimensional space.

hal-01340134, v1 : One-dimensional elastic collisions in a Platonic quadridimensional space.

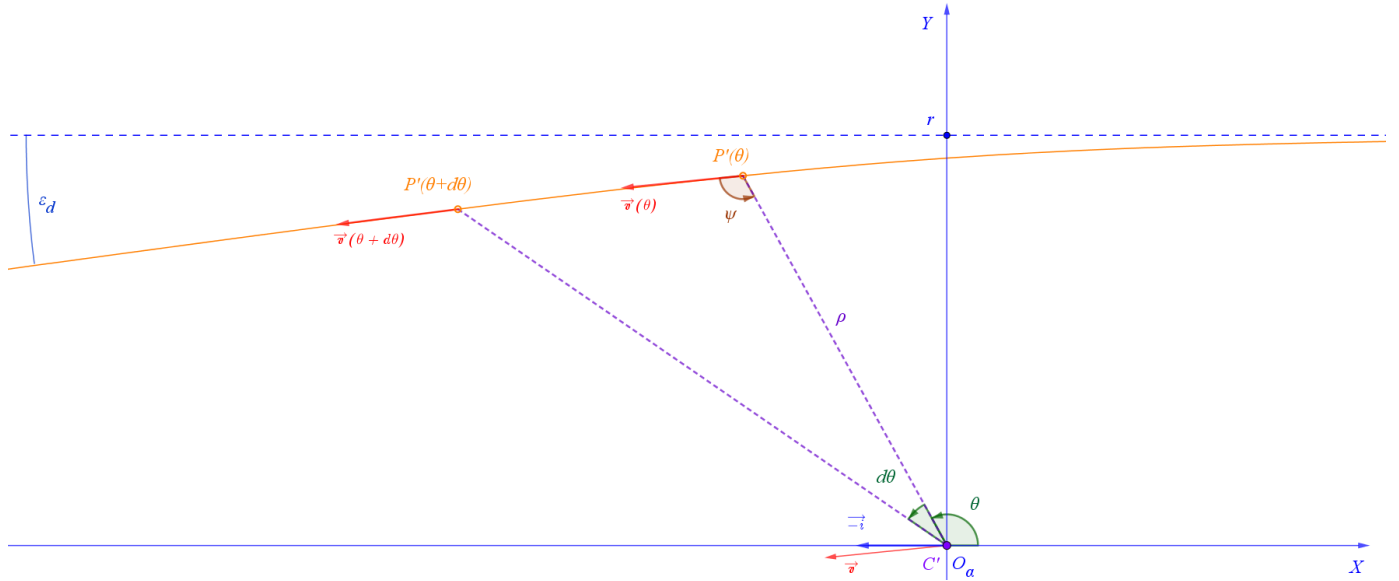
hal-01378215, v1 : About time measurement in a Platonic quadridimensional space.

hal-01584918, v1 : A quantified approach to the laws of gravitation in a Platonic quadridimensional space.

hal-01756323, v1 : De Broglie waves and quantification of Keplerian orbits in a Platonic quadridimensional space.

hal-01970150, v1 : An introduction to quantified variations of absolute time in the presence of a gravitational field in a Platonic quadridimensional space.

2. Diagram illustrating this study: trajectory of the photon observed in the reference frame R_α



Observers of a reference frame R_α study the apparent movement of a photon P' moving in the gravitational field generated by a massive body C' at rest in R_α and located in O_α .

These two objects are in fact the projections of the two corresponding objects P and C in movement in the Platonic space (cf. the articles cited in the reference).

In the absence of this field, the photon would move along the line whose equation is $Y = r$.

Let us denote by β_1 and β_2 the measures of the angles formed by the velocities \vec{v}_1 and \vec{v}_2 of these two objects with the hyperplanes of respective equations $W = W(P)$ and $W = W(C)$;

by ε the measure of the angle formed by the vector $-\vec{i}$ and the absolute velocity \vec{v} of the photon P' : $\varepsilon = (-\vec{i}, \vec{v})$.

In the particular case of this study, we chose $\beta_1 = 0$, $\beta_2 = \frac{\pi}{2}$, and the measurement of the angle ε will vary from $\varepsilon = 0$ (at the beginning of the observation) to $\varepsilon = \varepsilon_d$ (at the end of the observation).

The trajectories of P' and C' here observed in the reference frame R_α are the projections of the trajectories of the objects P and C into the Platonic space.

To simplify the calculations, the observation frame chosen is $R_{\pi/2}$, the trajectories of P' and C' in this reference frame are in a plane whose equation is $Z = Z_0$, the axes of $R_{\pi/2}$ are positioned so as to have their origin $O_{\pi/2}$ on the axis (OW) and their guiding vectors $\vec{i}_{\pi/2}$, $\vec{j}_{\pi/2}$, $\vec{k}_{\pi/2}$ coincide with the guiding vectors \vec{i} , \vec{j} , \vec{k} of the axes (OX) , (OY) , (OZ) .

Axes $(O_{\pi/2}Z)$ and (OZ) are not shown.

The purpose of this article is to estimate the value of the deflection ε_d , from the quantified results set out in articles hal-01756323 and hal-01970150.

3. Platonic modeling of the gravitational deflection of light

The measurement of the gravitational deflection of the trajectory of the photon P will be estimated **from the conjugation of two quantified phenomena**, linked to the De Broglie mass waves generated by the massive body C .

- The first phenomenon is due to the second postulate of quantified declination, that is to say (see article hal-01756323, page 5):

« when the body C_j perceives an occurrence of the mass waves generated by the body C_i , the direction of the vector $\overrightarrow{v_{abs j}}$ is modified by a quantum $\Delta\varepsilon_{i,j}$, independent of the reference frame R_α and of the rest mass of the considered body, which is equal to:

$$\Delta\varepsilon_{i,j} = \frac{Gh}{c^3 (d_{i,j})^2} \cdot \frac{\sin \psi}{\cos \beta_i + \cos \beta_j} . »$$

According to article hal-01756323 (page 7), the conservation of the global angular momentum leads to:

$$\frac{d\varepsilon}{dT} = \frac{Gh}{c^3 \rho^2} \cdot \frac{1 + \cos \beta_1 \cos \beta_2}{\cos \beta_1 + \cos \beta_2} \cdot \sin \psi \cdot \left[\sum_{i=1}^{i=2} \frac{\sin \beta_i}{\Delta w_{0i} (\sin^2 \beta_i + \cos^2 \beta_i \cos^2 \psi)} \right]$$

and, moreover, the geometric considerations studied in this same article (page 10) show

that we have:

$$\frac{d\theta}{dT} = \frac{\cos \beta_i}{\rho_i} \sin \psi .$$

Hence here, for $\beta_1 = 0$ and $\beta_2 = \frac{\pi}{2}$: $\frac{d\varepsilon_1}{dT} = \frac{Gh}{c^3 \rho^2 \Delta w_0} \sin \psi$ and $\frac{d\theta}{dT} = \frac{\sin \psi}{\rho}$.

These two relations lead to: $d\varepsilon_1 = \frac{Gh}{c^3 \rho \Delta w_0} d\theta$. [1]

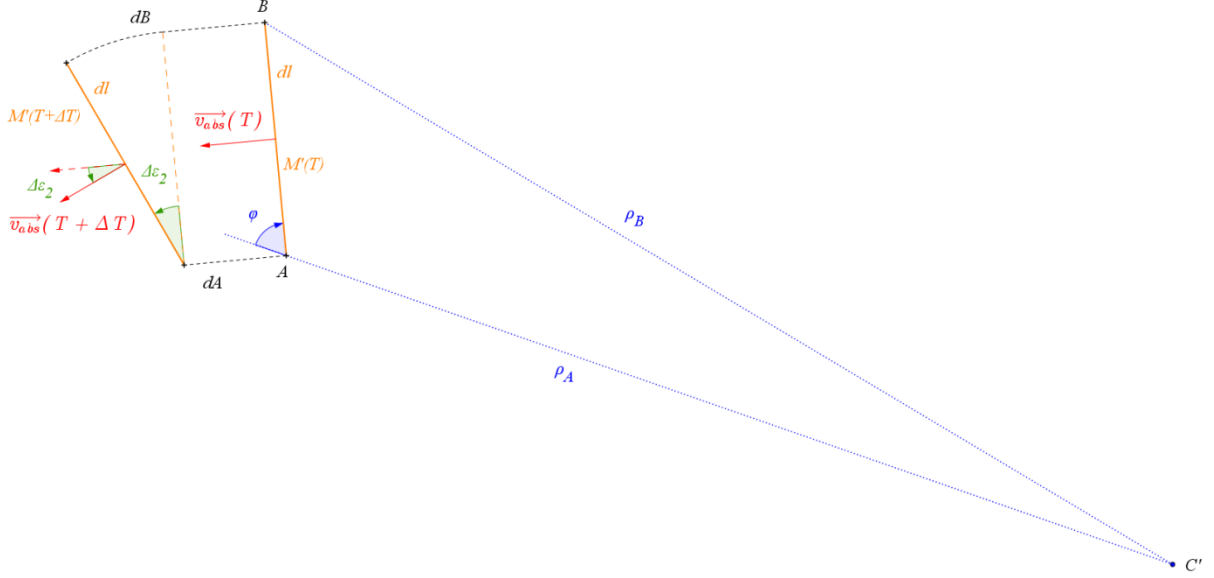
The deflection being small, we have $r \approx \rho \sin \theta$ (cf. diagram in paragraph 2.).

Thus, the relation [1] becomes:

$$d\varepsilon_1 = \frac{Gh}{c^3 r \Delta w_0} \sin \theta d\theta .$$
 [1b]

- The second phenomenon is a consequence of **the conservation of the energy of the system**, exposed in the article hal-01970150 : **the quantified variation of the absolute time in the presence of a gravitational field**.

Let us consider a non-point mobile M' , whose small spatial extent is equal to dl in the direction orthogonal to the direction of its displacement and whose modulus of absolute speed is $v_{abs} = \cos \beta_1$:



According to article hal-01970150 we then have, for an occurrence of the mass wave (by noting ΔT the period of the mass wave measured in $R_{\pi/2}$) :

$$dA = \left(\Delta T - \frac{Gh}{c^3 \rho_A} \right) \cos \beta_1 \quad \text{and} \quad dB = \left(\Delta T - \frac{Gh}{c^3 \rho_B} \right) \cos \beta_1.$$

Furthermore, the spatial extent dl being small in front of ρ_A and ρ_B , we can use the approximation $\rho_B \approx \rho_A + dl \cos \varphi$.

$$\text{Which leads to : } dB - dA = \frac{Gh}{c^3} \left(\frac{1}{\rho_A} - \frac{1}{\rho_B} \right) \cos \beta_1 = \frac{Gh}{c^3} \cdot \frac{dl \cos \varphi}{\rho_A \rho_B} \cos \beta_1.$$

By noting $\Delta \varepsilon_2$ the quantified declination thus generated by this slight difference in displacement $dB - dA$, and by noting $\rho = \rho_A \approx \rho_B$, it comes, whatever the length dl :

$$\Delta \varepsilon_2 = \frac{dB - dA}{dl} = \frac{Gh}{c^3 \rho^2} \cos \varphi \cos \beta_1. \quad [2]$$

$$\text{Furthermore, we have } \varphi + \psi = \frac{\pi}{2}, \text{ hence : } \Delta \varepsilon_2 = \frac{Gh}{c^3 \rho^2} \sin \psi \cos \beta_1. \quad [2b]$$

Finally, we recall that the absolute frequency of the mass wave generated by the massive body C is here (in m^{-1}): $v_{abs} = \frac{1}{\Delta w_0}$ (cf. article hal-01207447),

$$\text{which leads, with } \frac{d\varepsilon_2}{dT} = v_{abs} \Delta \varepsilon_2 \text{ and [2b], to: } \frac{d\varepsilon_2}{dT} = \frac{Gh}{c^3 \rho^2 \Delta w_0} \sin \psi \cos \beta_1;$$

and therefore, with $\frac{d\theta}{dT} = \frac{\sin \psi}{\rho}$ and $r \approx \rho \sin \theta$, we have :

$$d\varepsilon_2 = \frac{Gh}{c^3 \rho \Delta w_0} \cos \beta_1 d\theta, \quad \text{i.e.} \quad d\varepsilon_2 = \frac{Gh}{c^3 r \Delta w_0} \cos \beta_1 \sin \theta d\theta. \quad [2c]$$

- Considering that the observed photon is a non-point object, the differential deflections $d\varepsilon_1$ and $d\varepsilon_2$ thus lead to a **total differential deflection**
 $d\varepsilon = d\varepsilon_1 + d\varepsilon_2$ whose value is given by (cf. [1b] and [2c], with $\beta_1 = 0$):

$$d\varepsilon = 2 \frac{Gh}{c^3 r \Delta w_0} \sin \theta d\theta. \quad [3]$$

By integration of [3], by varying the angle θ from 0 to π , we can thus estimate the deflection ε_d of the trajectory of the photon P during the passage near the massive body C :

$$\varepsilon_d = \int_0^\pi 2 \frac{Gh}{c^3 r \Delta w_0} \sin \theta d\theta = 2 \frac{Gh}{c^3 r \Delta w_0} [-\cos \theta]_0^\pi$$

$$\text{i.e.} \quad \varepsilon_d = \frac{4Gh}{c^3 r \Delta w_0} \quad \text{or, with } \Delta w_0 = \frac{h}{cM_0} \text{ (*)}: \quad \varepsilon_d = \frac{4GM_0}{c^2 r}.$$

In particular, for a photon passing near the sun, with $M_0 = 1,989.10^{30} \text{ kg}$

and $r = 6,9551.10^8 \text{ m}$, we find for deflection $\varepsilon_d \approx 8,495.10^{-6} \text{ rad}$,

which corresponds to the result measured experimentally:

$$\varepsilon_d \approx 1,75 \text{ arc second.}$$

(***N.B.** : the mass of the body C is approximately equal to the sum of the masses of the elementary particles which constitute it.

The stratification distance Δw_0 taken into account in the calculations on the basis of the relation $\Delta w_0 = \frac{h}{cM_0}$ is a fictitious distance which mathematically makes it possible to

generate the occurrences of the mass waves corresponding to the sum of the occurrences generated by all of these particles.

Remember, a natural limit for the mass of an "elementary particle" is the Planck mass,

whose value at rest is: $m_p = \sqrt{\frac{hc}{2\pi G}} \approx 2,176.10^{-8} \text{ kg}$ and whose corresponding

stratification distance Δw_{0P} (ie its Compton wavelength) is :

$$\Delta w_{0P} = \lambda_c = \frac{h}{m_p c} = 2\pi \sqrt{\frac{Gh}{2\pi c^3}} = 2\pi l_p \approx 1,015.10^{-34} \text{ m}.$$

4. Conclusion

Articles hal-01584918 and hal-01756323 offer a first quantified Platonic approach to Keplerian mechanics.

In particular, they create links between these laws and the De Broglie mass waves generated by interacting bodies, through quantified changes of direction in their Platonic velocities.

By introducing a second postulate of quantified declination, article hal-01756323 also allows a quantified interpretation of the conservation of the absolute angular momentum of the system considered.

In addition, a comparative examination of these two articles, centered on the conservation of the absolute energy of the system, led to envisage in article hal-01970150 a quantified correction of the modulus of the Platonic speed of mobiles in a gravitational field.

In the relativist Platonic space, it should be emphasized that these quanta have an absolute character (they do not depend on the reference frames of observation) and are independent from the masses at rest of the bodies considered.

These postulates offer, in a relativistic framework, an astonishingly correct quantified approach to the classical laws of gravitation applied to elliptical Keplerian orbits.

And they allow, moreover, to quickly find several results proposed by the theory of general relativity and verified experimentally (cf. article hal-01970150). For example, the advance of the perihelion of the planets, the variations in the measurement of time in a satellite orbiting the Earth, the gravitational redshift ; and now we can add a quantified modeling of the gravitational deflection of light.

These numerous results and their examination can certainly be refined and supplemented, and the principles retained deserve, of course, to be further enriched and deepened.

However, these results are obtained rapidly and systematically, by an original and quantified way. What should, at least, raise new and numerous questions; especially about the deep links that this modeling reveals between the quantum effects of the De Broglie mass waves and the laws of gravitation.

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