More direct methods to evaluate general relativity effects. The influence of the age of the Universe

Corneliu BERBENTE*,[1], Sorin BERBENTE*,[1,2]

*Corresponding author
[1]"POLITEHNICA" University of Bucharest, Faculty of Aerospace Engineering, Department of Aerospace Sciences "Elie Carafoli",
Str. Polizu 1-7, sector 1, 011061 Bucharest, Romania,
berbente@yahoo.com
[2]INCAS – National Institute for Aerospace Research "Elie Carafoli",
B-dul Iuliu Maniu 220, 061126 Bucharest, Romania,
berbente.sorin@incas.ro

DOI: 10.13111/2066-8201.2022.14.4.3

Received: 05 September 2022/ Accepted: 21 October 2022/ Published: December 2022

Abstract: *More direct methods are given to evaluate the general relativity effects by simplifying the solving the solution of the extremum of variational problem to one variable only.*
The influence of the age of the Universe is mainly related to the variation of the coefficient of gravity the age of the Universe.

Key Words: *Euler problem, refraction coefficient, HD-graviton, modified frequency*

1. INTRODUCTION

The general relativity effects are related to the Einstein tensorial equation [1]:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi f_N(t_U)}{c^2} T_{\mu\nu} \tag{1}$$

where $R_{\mu\nu}$, $g_{\mu\nu}$, f_N, $T_{\mu\nu}$, R are: the tensor of curvature [2], the metric tensor (related to the element of Universe), the coefficient of gravity (variable with the Universe age, t_U,) the mass tensor and the Ricci tensor [2]. c is the speed of light in vacuum.

The gravitational constant (or better said "the coefficient of universal attraction") was included to compare the precision of determination.

The element of Universe dS is [8]:

$$(dS)^2 = \frac{1}{n}(cdt)^2 - n(d\vec{r})^2 \tag{2}$$

n being **the refraction index.**

Then the speed of light in a gravity field created by a mass M_0, is

$$c_n = \frac{c}{n} \tag{3}$$

The refraction index will be determined in the following.

2. THE DETERMINATION OF THE REFRACTION INDEX

One considers the potential energy of a particle in a gravity field given by a mass M_0:

$$U = -\frac{f_N M_0}{r + \frac{R_S}{2}}; R_s = \frac{f_N M_0}{c^2} \tag{4}$$

R_S being the SCHWARTZSHIELD RADIUS [4;6].

The potential energy will be added to the energy of the photon as follows:

$$E_{tot} = h\nu_\infty + U = h\nu; \nu = \frac{\nu_\infty}{\sqrt{n}}. \tag{5}$$

ν_∞ being the photon frequency at infinity.

The refraction index is given by:

$$n = \left(\frac{r + \frac{R_S}{2}}{r - \frac{R_S}{2}}\right)^2; ln(n) \approx 4\frac{R_S}{2r} = \frac{2f_N M_0}{c^2 r} \tag{6}$$

3. THE DETERMINATION OF THE PHOTON DEVIATION IN A GRAVITY FIELD

This problem was first solved, neglecting the general relativity effects, by Cavendish [3] who found the deviation angle δ_{CAV}:

$$\delta_{CAV} \approx \frac{2f_N M_0}{c^2 R_{sun}}. \tag{7}$$

Cavendish used the Newton equation in the form:

$$\frac{m_P}{\sqrt{1 - V^2/c^2}}\frac{dV}{dt} = -\frac{m_P}{\sqrt{1 - V^2/c^2}}\frac{f_N M_0}{r^2} \tag{8}$$

where m_P, V are the particle mass and velocity in the direction of the coordinate r, measured from the Sun center.

Even for $m_P = 0$ (photon mass) equation (8) can be simplified as follows:

$$\frac{dV}{dt} = -\frac{f_N M_0}{r^2} \tag{9}$$

Equation (9) was the one used to find the deviation (7).

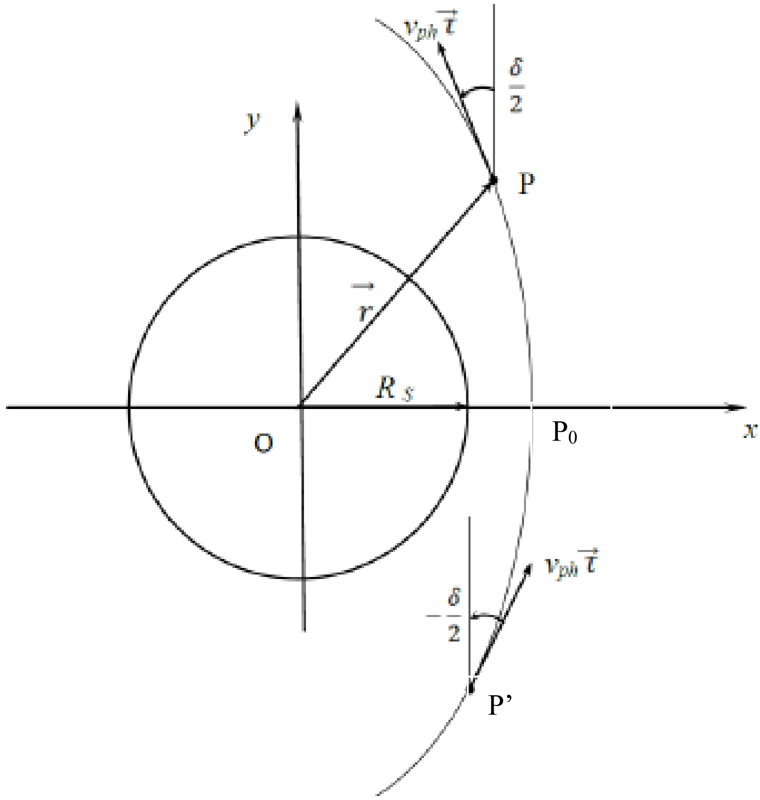

Fig. 1

To include general relativity effects, one uses a variational method [7] as follows: one simplifies the calculations, by reducing the problem to one variable problem (Euler problem), writing (see relation (2)):

$$\frac{dS}{dt} = \sqrt{\frac{c^2}{n(r)} - n(r)(r')^2} = F(t, r, r') \tag{10}$$

Then the extremum of the integral from (7) is the solution of the Euler equation [8]:

$$F_r - \frac{d}{dt} F_{r'} = 0. \tag{11}$$

By calculating the derivative from (9), one obtains the differential equation:

$$\frac{d}{dt}(nV) + (1 + \beta^2 n^2)\frac{f_N M_0}{r^2 n} = 0. V = r'; \beta = V/c. \tag{12}$$

Instead of integrating equation (10) in the interval $(-\infty, +\infty)$, it is observed that the deviation δ (see Fig. 1 where $\vec{\tau}$ is the unit vector tangent to the photon trajectory) is obtained by a velocity component in the vicinity of the intersection of the Ox axis with the photon trajectory.

Then, equation (9) integrates along Ox in the vicinity of this intersection, for a time interval $\Delta t = R_{Sun}/c$.

In this way one obtains the value (7).

One the other hand, by considering the following approximations at $r = R_{Sun}$: $n \approx 1 \approx const.$, and $(1 + \beta^2 n^2) \approx 2$, equation (10) becomes:

$$\frac{dV}{dt} + 2\frac{f_N M_0}{r^2} = 0. \tag{13}$$

A comparison of equation (7) and (13) gives a double value $(2\delta_{CAV}\}$, i.e. 1.74 seconds, instead of 0.87 seconds.

Thus the value of general relativity is restored.

4. THE INFLUENCE OF THE AGE OF THE UNIVERSE

The influence of the age of the Universe (time t_U) acts through the gravity coefficient $f_N(t_U)$ from equation (1), where $t_U = 0$ at BIGFLASH.

This will modify the values of the refraction index very little, but will change more the deviations of the photon in the gravity field (see relations (7) and (13)).

For example, for $t_U = 10$ billion years (instead of 13.8 billion years, the actual age of the Universe}, the deviation of photon by the Sun increases by 1.38 times, as the coefficient f_N increases by $1/t_U$ [3;5].

As for the refraction index, the modification is negligible.

In order to verify the Sun mass and the Sun surface at $t_U = 10$ billion years, the following data were used (see Google):

1: Sun Mass: $2.E30kg$;

2: Sun flux:1373 Wm^{-2};

3: Sun surface: 6.09E18 m^2 ;

4: Sun radius: $R_{Sun} = 696340km$.

The conclusion is that differences can be neglected.

5. CONCLUSIONS

More direct methods are given to evaluate the general relativity effects by reducing the solution of the extremal variational problem to a single variable only.

The influence of the age of the Universe is mainly related to the variation of the coefficient of gravity with the age of the Universe.

Also, the Universe curvature in Einstein equation (1), is modified by the same factor as $f_N(t_U)$.

Although the refraction factor is amplified by the same factor, the resulting effect is negligible.

REFERENCES

[1] A. Einstein, Die Grundlage der allgemeinen Relativitätstheorie, *Annalen der Physik*, vol. **354**, issue 7, pages 769-822, 1916.

[2] L. Jalbă, O. Stănăşilă, *Vectori, tensori, câmpuri (de la concepte la aplicaţii)*, Fundaţia Floarea Darurilor, Bucureşti, 2015.

[3] C. Berbente, A Physical - Geometrical Model for an Early Universe, *INCAS BULLETIN*, (online) ISSN 2247–4528, (print) ISSN 2066–8201, ISSN–L 2066–8201, vol. **6**, Issue 4, p. 3-12, Oct. - Dec. 2014, http://dx.doi.org/10.13111/2066-8201.2014.6.4.1

[4] N. Ionescu-Pallas, *General Relativity and Cosmology* (in Romanian), Buc., Ed. Şt. Enciclop., 1980.

[5] C. Berbente, A Hydro-Dynamical Model for Gravity, *INCAS BULLETIN*, (online) ISSN 2247–4528, (print) ISSN 2066–8201, ISSN–L 2066–8201, vol. **8**, Issue 1, p. 39- 47, Jan. - March. 2016, http://dx.doi.org/10.13111/2066-8201.2016.8.1.5

[6] C. Berbente, S. Berbente, Possible Simple Structures of the Universe to Include General Relativity Effects, *INCAS BULLETIN*, (online) ISSN 2247–4528, (print) ISSN 2066–8201, ISSN–L 2066–8201, Vol. **2**, Issue 4, pag. 11-20, October-December 2017, https://doi.org/10.13111/2066-8201.2017.9.4.2

[7]. C. Berbente, S. Berbente, M. Brebenel, An extension of newton gravity formula, *INCAS BULLETIN*, (online) ISSN 2247–4528, (print) ISSN 2066–8201, ISSN–L 2066–8201, vol. **11**, issue 2, p. 45-52, 2019, https://doi.org/10.13111/2066-8201.2019.11.2.4

[8] P. Rastall, An improved theory of gravitation, *Canad. J. of Physics*, vol. **46**, nr. 19, oct. 1968.

[9] I. Gh. Şabac, *Matematici speciale*, vol. **2**, Ed. Didactică şi Pedagogică, Bucureşti, 1965.