ISSN: 2639-0108

Research Article

Advances in Theoretical & Computational Physics

Passage of Cosmic Photons Over Stellar Limbs

Hans J. Fahr

Argelander Institut für Astronomie, Universität Bonn, Auf dem Hügel 71, 53121 Bonn (Germany)

***Corresponding author**
Hans J. Fahr, Argelander Institut für Astronomie, Universität Bonn, Auf dem Hügel 71, 53121 Bonn (Germany).

Submitted: 16 Nov 2021; **Accepted:** 22 Nov 2021; **Published:** 27 Nov 2021

Citation: *Hans J. Fahr. (2021). Passage of Cosmic Photons Over Stellar Limbs. Adv Theo Comp Phy, 4(4), 301-303.*

Abstract

In several preceding papers [1,2,3,4] we have discussed particle and photon propagations through cosmic gravity fields under the new aspect that gravitational field sources are seen by moving masses or photons under relativistically aberrated positions. This causes astonishing effects like the reduction of peculiar motions of stars or a permanent increase of redshifts of photons at their propagations through cosmic space with uniform matter distribution. In this paper here we shall, however, now study under the given new auspices of relativistically displaced gravity sources the passage of photons over the limbs of stellar surfaces and ask whether such photons not only thereby experience the well known and proven Einstein 'ian deflection, but may also be subject to a discrete, asymptotic energy loss which is related to the mass of the touched star and the impact distance of the photon from this star. We shall investigate here this effect and compare it with Einsteinìan expectations.

Introduction

In a preceding paper of us [3] we have studied the effect that gravitational field sources are recognized by massive objects or photons at aberrated positions displaced from the true ones, just like electromagnetic radiation sources - like stars in our galactic neighbourhood - are seen as displaced from their true positions when observed from moving reference systems (well known as "stellar aberration effect", since James Bradley, 1725). This analogy to the "optical", electromagnetic effect becomes clear, when bringing to our minds that according to present understandings gravity fields are communicated in space by gravitons, just like electromagnetic fields are communicated by electromagnetic quanta like photons. This will clearly tell us that the classical optical aberration effect will also occur in gravitational dynamics as long as the quanta of the gravitational fields are propagating with the same speed as the quanta of the electromagnetic fields, namely with the speed c of light.

On this basis Fahr and Heyl [3] have investigated what effect, due to this aberrational dislocation of cosmic gravity sources, has to be expected on moving masses or propagating photons. Hereby it turned out that peculiar motions of stars in uniform cosmic matter environments are reduced in the advance of cosmic time and that photons propagating through a cosmos with uniform matter distribution will permanently undergo a redshift of their frequencies. Thus even in a non-expanding universe photons get redshifted, even so much that the early stellar photons during the present age of the universe of 13.7 Gigayears are nowadays contributing to the cosmic -background radiation (i.e. the CMB - Cosmic Microwave Background).

The question, however, which has not yet been looked at under these new auspices is what happens to photons which closely pass by at specific gravity sources, like e.g. at stars. Do such photons also lose energy at such occurences, - an effect perhaps overlooked by Einstein (1911) when treating the deflection of photons at nearby passages close to stars? This question we shall try to answer here in what follows.

Basic calculation

In the following calculation we mainly follow the often offered simplified text book calculation used by several authors like Sexl and Sexl (1979) [5] demonstrating the Einsteinìan effect of an angular deflection of a photon that on its way just touches the outer photospheric limb of a star, e.g. like the Sun. Assuming, which in fact is legal to do for non-collapsed stellar objects (i.e. stellar radius $r_s >> R_s$ = Schwarzschildradius), that the influence on the photon trajectory by the gravity field of the star is linearizably small, then simply allows to add up the total gravitational action upon the photon by integrating it up along the unperturbed photon trajectory (e.g. a straight line along the x-axis touching the stellar limb).

Then, under the classical Einstein 'ian view, the photon would gain energy, till it reaches the peristellar point y= rs at the periphery of the star closest to the center of the star, but loses exactly this amount of energy again when propagating out to infinity. This is why in Einstein's view [6] the photon only is deflected from its original direction by an angle $\delta=2GM/R_sc^2$, but conserves its frequency v or its energy (hv) when again moving to larger distances from the star (i.e. no final frequency change remains from the stellar passage!).

The question, however, could be asked now whether this is different when the relativistic aberration of the position of the stellar gravity center recognized by the photon at his passage has to be taken into account as discussed in earlier papers by [1,2,3,4]. Because then the photon on its trajectory along the x-axis permanently may recognize a component of the gravitational field acting in the direction opposite to the motion of the photon and thus changing the energy of the propagating photon. In the following we shall now calculate just this effect.

Considering the photon at a position x on its passage along the x-axis, it will while arriving at x have located the stellar gravity center in the rest frame of the system under an angle ϑ given by $\cos\vartheta = x/\sqrt{x^2+y^2}$, where $y = r_s$ is taken to be the closest distance of the x-axis to the stellar gravity center (see Figure 1). Now we shall take into account the relativistic fact that the moving photon will recognize the stellar gravity center under an aberrated angle ϑ' which is given by (see [3]):

$$\cos\vartheta' = \frac{\cos\vartheta + ß}{1 + ß\cos\vartheta}$$

where $ß = U/c$, U being the velocity of the massive object or the photon. In case of a photon thus $U = c$, and hence ß is given by ß=1. One consequently obtains the following relation between the angles ϑ and ϑ':

$$\cos\vartheta' = \frac{\cos\vartheta + 1}{1 + \cos\vartheta} = \pm 1$$

which means that along the whole passage to and from the star the photon is permanently recognizing the stellar gravity center under the same angle $\vartheta' = 0°$ at $x < 0$ and under $\vartheta' = 180°$ at $x > 0$. This means the star by the passing photon is permanently recognized, as if its gravity center would act from the direction into which the photon propagates (while $x<0$) or opposite to this direction (while $x>0$). This expresses the fact that the photon gains energy on the way from $x=-\infty$ up to $x=0$, and loses the same amount of energy from $x=0$ to $x=+\infty$. (see Figure 1).

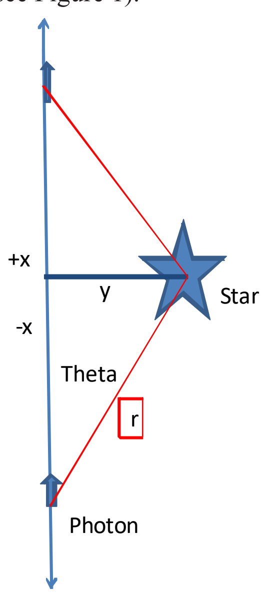

Figure 1: Illustrative view of the stellar limb passage of a photon

The change of the photon energy ($h\nu$) at the photon propagation along the x-axis as function of the space coordinate x, in view of the work done against the stellar gravity, thereby is given by

$$d(h\nu)) = -dx\frac{(h\nu)}{c^2}\frac{GM}{r^2}\cos\vartheta' = -dx\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\cos\vartheta'$$

Hence at the propagation of the photon from $x=-\infty$ to x hereby the photon frequency $\nu(x)$ thus undergoes a change which can be expressed by the following relation:

$$\nu(x) = \nu_\infty \exp[-\frac{1}{c^2}\int_{-\infty}^{x} dx\frac{GM}{x^2+y^2}\cos\vartheta']$$

where G is the gravitational constant and M is the mass of the star. For a photon propagating from $x=-\infty$ to $x=+\infty$ one thus finds when inserting $\cos\vartheta' \pm 1$ the following frequency change:

$$\nu(-\infty,+\infty) = \nu_\infty \exp[-\frac{1}{c^2}\int_{-\infty}^{x=0} dx\frac{GM}{x^2+y^2} + \frac{1}{c^2}\int_{x=0}^{+\infty} dx\frac{GM}{x^2+y^2}] = \nu_\infty$$

i.e. no change of the photon frequency as already obtained in the Einstein´ian case [5,6].

There still exists, however, a difference with respect to this case which is easily recognized when one looks for the stellar gravitational force component which acts purely perpendicular to the propagation of the photon at its passage over the stellar limb. For that reason, we now look to this force component, and in the stellar rest frame would find a component perpendicular to the photon motion given by:

$$K_\perp(h\nu)) = -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\sin\vartheta$$

Now under the new auspices that the propagating photon recognizes the position of the stellar gravity center instead at an angle ϑ, at an aberrated angle ϑ′, one now obtains the perpendicular force in the form:

$$K_\perp(h\nu)) = -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\sin\vartheta' = -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\sqrt{1-\cos^2\vartheta'} = -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\sqrt{1-(\frac{\cos\vartheta + ß}{1+ß\cos\vartheta})^2}$$

and inserting here that for photons with $\beta = U/c = 1$ one obtains the interesting result:

$$K_\perp(h\nu)) == -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\sqrt{1-(\frac{\cos\vartheta + ß}{1+ß\cos\vartheta})^2} = -\frac{h\nu}{c^2}\frac{GM}{[x^2+y^2]}\frac{\sqrt{1-\cos^2\vartheta+\cos^2\vartheta-1}}{1+\cos\vartheta} = 0!$$

expressing the fact that along the whole passage of the photon along the x-axis no force component perpendicular to this axis should be acting, as if no gravity field would be present, and thus no deflection of the photon from the x-axis should occur.

This interestingly means that the photon when crossing the gravity field of a star neither will change its energy (hν) or frequency ν, a result which agrees with Einstein's view [6], nor should it change its direction of propagation - a result which disagrees with Einstein. The latter point obviously also is in contradiction to the radio observations of radio astronomers [7,8]. Obviously there exists a scientific conflict which needs to be dissolved.

Conclusion

In this article we have made use of the standpoint justified by [1,2,3,4] that not only electromagnetic radiation sources, but as well gravitational sources in space from moving objects, like massive particles or photons, should appear at aberrated, dislocated positions. This aberration should evidently occur - like in the analogous electromagnetic case (see: stellar aberration, James Bradley), 1725), as long as gravitational fields are communicated to space by gravitons analogous to electromagnetic radiation fields by electromagnetic photons, and as long as both field quanta propagate with the same velocity $c=c_g=c_e$. These latter points are, however, commonly believed in present day modern physics. On this basis then we have to expect aberrations in the recognition of gravitational source positions by moving massive objects or photons as already discussed by [1,2,3,4]. Here in this article we have shown that due to this relativistic dislocation of a gravitational source like a star aberrational effects should also occur in case a photon closely passes by over the photospheric limb of a star. As we have shown here the photon even due to this aberrational effect will not change its energy at such a limb passage, however, due to this aberrational effect at the same time the photon will also see the center of the stellar gravity field displaced in such a way that no force component perpendicular to its passage line appears. This means the photon should pass the star undeflected, which would be in contrast to Einstein's prediction of a deflection angle by $\delta=2GM/R_sc^2$. Also the lensing effects observed by astronomers at stars appearing for us behind a for ground massive galaxy need to be newly interpreted in this new view. We are waiting herewith for a timely solution of this conflicting scientific situation.

References

1. Fahr, H. J., & Heyl, M. (2020). A universe with a constant expansion rate. Physics & Astronomy International Journal, 4(4), 156-163.
2. Fahr, H. J., & Heyl, M. (2019). Stellar matter distribution with scale-invariant hierarchical structuring. Physics & Astronomy International Journal, 3(4), 146-159.
3. Fahr, H.J. and Heyl, M. (2020). Redshifting cosmic photons in a non-expanding universe, Advances Theoretical Computational Physics, 3(3), 220-226.
4. Fahr, H.J. and Heyl, M. (2020). Energy change of particles and photons at crossing gravity fields of galaxy clusters or single stars: The concept of gravitatons. Advances in Theoretical & Computational Physics, 3(4), 239-242.
5. Sexl, R., & Sexl, H. (1979). Weiße Zwerge-Schwarze Löcher. Einführung in die relativistische Astrophysik. Weiße Zwerge-Schwarze Löcher. Einführung in die relativistische Astrophysik.
6. Einstein, A. (1911). Translated from "Über den Enfluss der Schwerkraft auf de Ausbrevtung des Lnchtes," Annalen der Physik, 35.
7. Fomalont, E. B., & Sramek, R. A. (1976). Measurements of the solar gravitational deflection of radio waves in agreement with general relativity. Physical Review Letters, 36(25), 1475.
8. Fomalont, E. B., & Sramek, R. A. (1977). The deflection of radio waves by the sun. Comments on Astrophysics, 7, 19-33.