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Research Article

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Energy Change of Particles or Photons at Crossing Gravity Fields of Galaxy Clusters or Single Stars: The Concept of Gravitons

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Abstract
We investigate the gravitational action of cosmic mass associations, like stars or stellar clusters, on moving massive objects. Hereby the relativistic effect of propagating field quanta communicating the position of gravity sources by means of so-called gravitons is taken into account. In case of moving objects this causes an aberration of the recognized actual location of the cosmic mass sources with respect to their positions in the cosmic rest frame. The astonishing effect of that position retardation is that a moving objekt, even if it moves right through the center of a centrally symmetric cluster mass association, experiences a net gravitational braking and energy loss. Applying this view to the problem of a planetary object orbiting around a central mass like the sun, then it turns out that the orbiting planet permanently reduces its orbital angular momentum, since permanently experiencing a gravitational force component antiparallel to its orbital motion. From that an orbital decay time can be derived which for a terrestrial planet would imply the spiralling-in period of only a few 10^3 years. Compared to the age of the planet earth of about 4. 5 Billion years this represents a big problem of understanding. In this article we cannot offer a rational solution of this problem and thus we simply end with the recommendation to perhaps reinvestigate the theoretical concept of gravitons thought to be the quantum messengers of gravitational fields.

Introduction
In two recent papers we have studied the relativistic effects that cosmic objects, when moving along their trajectories through the gravitational fields of the ambient masses of the universe, see the positions of discrete cosmic mass sources like stars, galaxies or galaxy clusters displaced with respect to their real positions given in the cosmic rest frame [1, 2]. This aberration phenomenon, well known amongst astronomers in its electromagnetic analogue as stellar aberration phenomenon, has most interesting effects on the motion of such objects, especially connected with a general "braking effect", i.e. the effect that peculiar velocities of massive objects are permanently reduced in magnitude at the progress of cosmic time, and the analogue effect onto cosmic photons that they are permanently increasing their redshifts the longer they propagate through the universe. These effects are most surprising in all their convincing consequences and have encouraged us here in this paper to apply these relativistic gravitational aberration effects in ambient cosmic gravity fields also now to more local and smaller-scaled motions like those of objects and photons through the gravity fields of galaxy clusters or even to Keplerian motions of planetary bodies orbiting their parent central stars. And again at these new applications the results which we derive here are highly surprising, shocking and still looking for observational confirmations and interpretations. In this paper here we are not presenting a very conclusive result, but we are essentially only raising questions and want other scientists from the astronomical community to follow us in these thinkings. Maybe in view of these results we are going so far as to say that the physics of gravitons - thought to be the light-fast messengers of gravitational fields - has to be newly conceived.

Crossing of A Galaxy Cluster
First we want to study here the change in energy or redshift of a particle or a photon when crossing along a central straight line

$$\vec{r}(x) = \vec{r}_0 + x \cdot \vec{k}\text{ , with } \vec{k}$$

being a dimensionless unity vector, through a system of masses connected with, or realized by, the mass density distribution $\rho_c(r)$ in a galaxy cluster. Imagining this system as characterized by spherical mass shells centered around the center of the cluster at r=0, we may perhaps assume to have the following mass distribution represented by the mass density distribution $\rho_c(r) = \rho_c \exp[-x/x_0]$ around a central point r_c=0 of such a cluster:

where $\rho_{C,0}$ denotes the central mass density in the cluster.

Now we want to respect the fact that the locations of the sources of gravity, due to the finite propagation velocity vg=c of gravitons, are recognized or perceived by the particle or photon at "relativistically retarded" positions, and hence the direction of the gravitational pull with respect to the location of the real mass source experiences an aberration, i.e. is displaced by a certain angle δθ.

That means, if a corresponding mass element δM_C on a spherical mass shell of this cluster at a radial distance r is "gravitationally" seen by an object at rest with respect to the cluster center under an angle θ, it instead acts upon a propagating particle or photon effectively not from this direction *θ*, but from an apparently different direction *θ'=θ+δθ*, namely under this aberration angle θ', when viewed by the moving particle with velocity or the photon with a velocity $\vec{U} = U\vec{k}$ with respect to the local standard of rest.

According to SRT relations these two angles θ and θ´ for an object moving with a velocity $\vec{U} = U\vec{k}$ are connected by the following SRT Doppler relation [3]:

$$\cos\theta' = \frac{\cos\theta + \beta}{1 + \beta\cos\theta}$$

where β is given by β = U/c.
Taking the situation that an object is at a distance R from the center of the cluster (seeFigure 1 for illustration), then it is attracted by the gravitation of a mass element δM_C under an angle θ' given by the formula above, if this mass element in the rest frame of the cluster is located under an angle *θ*. This means an effective, attractive force acts which is given by

$$\vec{k} \cdot \delta\vec{K} = -G\delta M_C \frac{\cos\theta'}{s^2}$$

where s^2 is given by

$$s^2 = R^2 + r^2 + 2rR\cos\theta$$

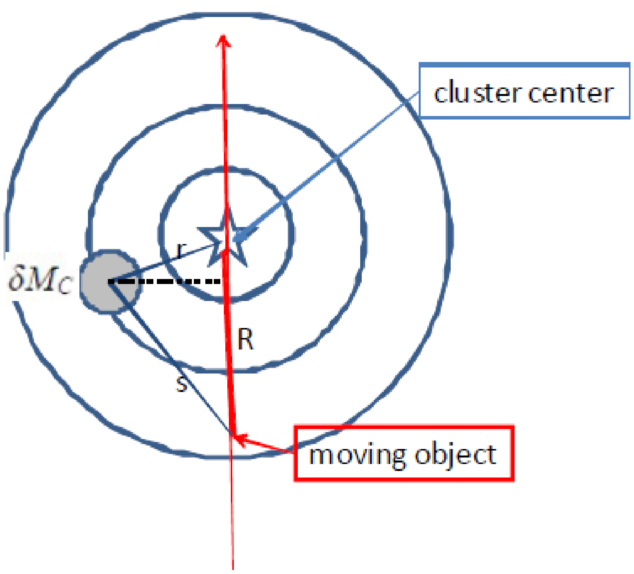

Figure 1: Illustration of a moving object crossing a cluster mass system.

Forces perpendicular to $\vec{k}$ cancel as long as the object is moving on a central line (i.e. a line crossing right through the center of the cluster at r=rc=0). Calculating now the integrated forces $\vec{K}$ in direction, $\vec{k}$ acting on the moving object at the place *R*, one obtains the following result:

$$K = -G\pi \int^{\theta}\int^{r} \rho_c(r) r^2 \sin\theta d\theta \frac{\cos\theta'}{R^2 + r^2 + 2rR\cos\theta} dr$$

Taking all things together we are left with the following expression:

$$K = -G\pi\rho_{C,0} \int^{\theta}\int^{r} \exp[-\frac{r}{r_0}] \sin\theta d\theta \frac{\frac{\cos\theta+\beta}{1+\beta\cos\theta}}{R^2 + r^2 + 2rR\cos\theta} r^2 dr$$

This relatively complicated double-integral expression simplifies into two separate integrals, if *R*=0, i.e. the object is located just in the center of the cluster, then yielding the following, easily hand able expression:

$$K = -G\pi\rho_{C,0} \int_0^{\infty} \exp[-\frac{r}{r_0}] dr \cdot \int_0^{\pi} \frac{\cos\theta + \beta}{1 + \beta\cos\theta} \sin\theta d\theta$$

As is evident here from, however, even in the cluster center at *R*=0, being surrounded by a spherically symmetric mass distribution of the cluster, the moving object experiences, as already shown in [1, 2], a net force given by:

$$K = -G\pi\rho_{C,0} r_0 \int_0^{\pi} \frac{\cos\theta + \beta}{1 + \beta\cos\theta} \sin\theta d\theta = -\frac{3}{4} G \frac{M_C}{r_0^2} [\frac{1-\beta^2}{\beta^2} \ln[\frac{1+\beta}{1-\beta}] - \frac{2}{\beta}]$$

where *Mc* denotes the total mass of the cluster. This result must perhaps at first glance appear counter-intuitive, since in the center of a symmetric mass distribution one would normally not expect any net gravitational forces to act, however, in case that the object in the center is moving with velocity *U*, then in fact there is a net force acting given by the upper expression. Also the general scientific wisdom, that inside a spherical mass shell no gravitational field is felt, does not hold for an object in motion there, because it sees the surrounding single mass elements on the spherical shell at asymmetrically displaced positions, and hence no spherical gravitational symmetry is valid for this object. This appears quite surprising, and therefore we still try now a different look onto this problem.

Trying an Alternative Access to the Problem

In the following part we shall look at the same physically prevailing situation, however we shall take a different view to it now. Again let us assume an object at a distance *R* from the cluster center, and now let us study the gravitational attraction through a cluster mass element *δMc*, appearing in the rest frame system of the cluster as seen from this object under an angle θ in a distance s from the object. Assuming now that the object is in motion with a velocity $\vec{U}$ then for this object in motion the mass source, i.e. the gravitation source δMc, appears at a velocity-dependent, Lorentz-contracted distance s´ instead of s, because the distance *z=Rcosθ* in direction of the motion $\vec{U}$ for the moving object appears Lorentz-contracted, while the distance *y=Rsinθ* perpendicular to is conserved [3-5]. Judged from the system of the moving object the total distance in this system thus is given by:

$$s'^2 = R^2\cos^2\theta \cdot (1-(U/c)^2) + R^2\sin^2\theta = R^2\sin^2\theta = R^2(1-\cos^2\theta \cdot (U/c)^2))$$

On the other hand due to the Lorentz-contracted distance in direction $\vec{U}$ the mass source δMc also now, under this alternative view, appears under a different angle θ´ instead of θ given by:

$$tg\theta' = y/z' = tg\theta \frac{1}{\sqrt{1-(U/c)^2}}$$

This demonstrates that in the case $U= c$, i.e. object, e.g. as a photon, moves with c, one obtains the information that under this condition all rest frame angles θ in the system of the photon appear under the angle $tg\theta' = \infty$, i.e. $\theta' = \pi/2$. This would, however, also have come out as the result from our earlier derivation, since for U/c=β the earlier expression

$$\cos\theta' = \frac{\cos\theta + \beta}{1 + \beta\cos\theta}$$

also simply would lead to cosθ′=1, meaning that $\theta' = \pi/2$.

The relation between angle θ in the rest frame and angle θ′ in the moving frame in view of the Lorentz-contracted distance s′ can thus also be expressed in following form:

$$\cos\theta' = \frac{y}{s'} = \frac{R\sqrt{1-\cos^2\theta}}{\sqrt{R^2(1-\cos^2\theta\cdot(U/c)^2)}} = \sqrt{\frac{1-\cos^2\theta}{1-(U/c)^2\cos^2\theta}}$$

Since this view again obviously leads to the same as the above astonishing result, we shall now dare to apply this special-relativistic view on the action of gravity sources to the well-known problem of Keplerian motions of objects around a central mass like the Sun.

Aberration of The Gravity Source for The Moving Object at Keplerian Motions

Regarding a planetary object orbiting the central gravity source, the Sun, in a quasicircular orbit, it is interesting to pay attention to the difference between the situation A: in the rest frame and B: in the frame of the moving planetary object. In the rest frame the object moving in a circular orbit around the sun, at its actual position with respect to the direction of its circular motion $\vec{U}$, sees the center of gravity, i.e. the sun, at an angle $\theta = \pi/2$ or $\cos\theta = 0$. In its own rest frame moving with $\vec{U}$, however, the object sees the gravity center at an angle θ′ which latter, with $\beta=U/c$, is given by:

$$\cos\theta' = \frac{\cos\theta + \beta}{1 + \beta\cos\theta} = (U/c)$$

This means, however, that instead of seeing the center of gravitation from the moving planet under the angle θ=900, it sees it under the angle $90^0+\delta\theta$ with $\delta\theta = -U/c$.

This also implies that there exists a gravitational force component acting on the moving planet at its circular motion antiparallel to its orbital velocity $\vec{U}$. Hence this force tends to reduce the orbital velocity U by the following amount

$$m\frac{d\vec{U}}{dt} = -\cos\theta' \frac{GmM_s}{R^2}$$

instantaneously causing a decrease of the orbital velocity U and leading to the following first-order equation of motion under the action of the first-order perturbation force $K_{11}=-(U/c)K$:

$$\frac{d\vec{U}}{dt} = -\frac{U}{c}\frac{GM_s}{R^2}$$

or expressed by:

$$\frac{d}{dt}\ln U = -\frac{GM_s}{cR^2}$$

or when introducing the relevant time of the orbital period of the earth around the sun with $Y_E = 2\pi R_E/U_E = 1$ *year:*

$$U(t) = U_E\exp[-\frac{GM_s}{cR_E^2}(t-t_0)] = U_E\exp[-\frac{GM_s 2\pi R_E}{cR_E^2 U_E Y_E}(t-t_0)] = U_E\exp[-\frac{c}{U_E}\frac{2\pi GM_s}{c^2 R_E}\frac{(t-t_0)}{Y_E}]$$

This, together with the Schwartzschild radius of the sun, $r_{ss} = 2GM_s/c^2$ finally leads to:

$$U(t) = U_E\exp[-\frac{c}{U_E}\frac{\pi r_{SS}}{R_E}\frac{(t-t_0)}{Y_E}]$$

This formula gives the message that a typical relativistic decay period of the quasi-circular spiralling-in orbital motion of e.g. the earth is given by about

$$\tau_E = (U_E/c)(R_E/\pi r_{SS}) \simeq 1.6\cdot 10^3 Y_E$$

indicating as a most astonishing result that circumsolar orbits at distances smaller than or equal to $R=R_E$ should have a decay period of only a few thousand years. How then the solar system and its planets could have reached an age 4.5 Billion years?

Completely different forces by their nature, however with a similar action, reducing the angular momentum of Keplerian objects and enforcing their spiralling-in motion, are known to be due to the so-called Poynting-Robertson forces that act upon dust grains orbiting the radiating sun [6]. For the typical spiraling-in period of these dust grains starting from a circular orbit at the Earth values of 10^6 to 10^7 years (i.e. Y_E) have been calculated by Grün and Svestka, substantially larger than the above derived period by about 3 orders of magnitude [7, 8]. This, in comparison with the above result for the relativistic Keplerian decay time raises the question, whether something, and especially what, in the above calculation might be wrong.

Conclusion

Even though the above presented theory of a Keplerian object under relativistic gravity effects of the Sun was simplified in many respects, the shocking result implying orbital decay times of terrestrial planets of only a few 10^3 years is fairly solid and hard to dethrone.

The above presented calculation had assumed a planetary orbit which at its loss of orbital angular momentum stays quasicircular over the whole decay period. This of course is not exactly true, but the permanent loss of angular momentum of the planetary object under the given conditions would turn the circular into an elliptical orbit, and a more reliable numerical calculation should be carried out, however, as can easily be proven, would not change the decay time period by an order of magnitude. Furthermore, in a more serious study it should be taken into account, that the system "Sun and Planet" is a two-body system, and hence the two objects both orbit around the mass center of this system. That means also the Sun is not fixed at a specific point, but with its center of gravity carries out a circular motion around the mass center of the system at a distance r_S=(mE/mS) r_E=3.10-6. As seen from the earth this pericentral motion implies a change in the sun´s position by an angle of

$$t_g \theta_s = r_s / r_E = 3.10^{-6}$$

or an angle of $\delta\theta \eqsim 3.10^{-6}$. This angle is much smaller than the special-relativistic aberration angle appearing for the moving planet which amounts to $\delta\theta$ = β=U/c=(30/300000)=10^(-4), i.e. in fact about two orders of magnitude smaller. Even though, when looking to the concerted motion of the planet and the Sun around the common mass center, there is no compensating phase coherence of the dislocations given, a numerical compensation of these dislocations is simply completely impossible in view of the differences in magnitudes of $\delta\theta_s$ and $\delta\theta_E$. Taking into account the special-relativistic dynamic mass of the moving planet also only would lead to a second order correction by $(U/c)^2$ and thus would not help to solve the problem.

That, at the end of this article, means that we do in fact at this moment not see any rational explanation for the very short orbital decay time periods of planets under special-relativistic gravitational action of the Sun which were calculated here in this article. At the moment this brings us to the challenging conclusion that perhaps the whole concept of gravitational fields being propagated to other gravitationally attracted massive bodies derived in a linearized version of the GRT field equations by Einstein (originally see Einstein, 1916) or later e.g. by Goenner (1996) must become again a subject of reinvestigations - perhaps one must finally conclude that there are in fact no gravitons, and that gravity fields in fact are no quantum fields, even though their existence has been claimed for since long ago (Davies), or they are perhaps faster than light.

At least since up to now there has been no success in the attempt to quantize gravity fields, i.e. Einstein's General Relativistic gravity fields, it must be allowed to also hesitate believing in the up to now given concept of gravitons as the quantum bosons of gravitational fields, expected as mass-less and with spin "2". It is an error to believe that with the recently installed big gravity wave antennas the existence of gravitons had been clearly verified. Maybe gravitational waves have been proven to exist with LIGO- or Virgo- observatories [9, 10], but gravitons up to the present have not been confirmed with these antenna devices [11]. But if in fact gravitational fields are no quantum fields, then one also might find therein the evident solution of the above presented decay problem. On the other hand, if the retardation of cosmic gravity fields due to the lack of gravitons can no longer be expected, then we had to confess that also our up-to-now well working cosmic photon redshift theory would not work anymore [1,2, 12-14].

References

1. Fahr H J, Heyl M (2020) A universe with constant expansion rate, Physics & Astronomy Intern. Journal 4: 156-163.
2. Fahr HJ, Heyl M (2020) Redshifting cosmic photons in a non-expanding universe, Advances in Theoret & Computat. Physics 3: 220-227.
3. French A P (1968) In: Special Relativity, Massachusetts Institute of Technology, 1968 Goenner, H.: Einführung in die spez. und allgem. Relativitätstheorie, Spektrum Akad.
4. Sexl R, Schmidt HK, Raum, Zeit, Relativität, et al. (1979) Braunschweig/Wiesbaden.
5. Nolting W (1991) Grundkurs: Theoretische Physik 4, Spezielle Relativitätstheorie/Thermodynamik, Verlag Zimmermann/Neufang, Ulmen.
6. Fahr HJ, Scherer K, Banaskiewicz M (1995) The evolution of the zodiacal dust cloud under plasma drag and Lorentz forces in the latitudinally asymmetric solar wind, Planet. Space Sci 43: 301-312.
7. Grün E, Svestka J (1996) Physics of the interplanetary and interstellar dust: Space Science Reviews 78: 347-360.
8. Grün E (2000) Dust in the solar system, in "The Outer Heliosphere Beyond the Planets", Copernicus Society, edited by Scherer, Fichtner, Marsch 2000: 289-325.
9. Abbott BP (2016) Observation of gravitational waves from a binary black hole merger, Physical Rev. Letters 116: 0611021-06110216.
10. Castelvecchi D, Witze W (2016) Einstein's gravitational waves found at last, NATURE NEWS 11.
11. Davies PCW (2013) The search for gravity waves, Cambridge University Press, 1980 Dyson, F.: Is a graviton detectable? Int. Journal of Modern Physics A, Einstein, A.: Näherungsweise Integration der linearisierten Feldgleichungen der
12. Virgo Collaboration, BP Abbott, R Abbott, T D Abbott, F Acernese, et al. (2017) Observation of a 50-solar-mass binary black hole coalescence at redshift 0.2, Physical Rev. Letters 118: 22.
13. Gravitation Sitzungsberichte d (1916) Preuß. Akad. Wiss., Berlin, Math. Nat. Kl 1916: 688-696.
14. Verlag (1996) Heidelberg-Berlin-Oxford 1996: 325-350.