



**HAL**  
open science

# Does General Relativity Theory Strongly Underestimate Gravitational Redshift for Objects Such as Black Holes and Quasars?

Espen Gaarder Haug, Spavieri Gianfranco

## ► To cite this version:

Espen Gaarder Haug, Spavieri Gianfranco. Does General Relativity Theory Strongly Underestimate Gravitational Redshift for Objects Such as Black Holes and Quasars?. 2022. <hal-03831552>

**HAL Id: hal-03831552**

**<https://hal.science/hal-03831552v1>**

Preprint submitted on 2 Nov 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

# Does General Relativity Theory Strongly Underestimate Gravitational Redshift for Objects Such as Black Holes and Quasars?

Espen Gaarder Haug\* and Gianfranco Spavieri<sup>+</sup>

\*Norwegian University of Life Sciences, Norway

e-mail [espenhaug@mac.com](mailto:espenhaug@mac.com) and [espen.haug@nmbu.no](mailto:espen.haug@nmbu.no)

ORCID <https://orcid.org/0000-0001-5712-6091>

<sup>+</sup>Centro de Física Fundamental, Universidad de Los Andes,

Mérida, 5101 Venezuela. E-mail: [gspavieri@gmail.com](mailto:gspavieri@gmail.com)

ORCID <https://orcid.org/0000-0003-4561-2599>

October 27, 2022

## Abstract

General relativity theory ignores Lorentz relativistic mass. The rejection of Lorentz relativistic mass by the general relativity research community has happened without first properly investigating what predictions incorporating it have led to. Recent published research has shown it leads to simpler and more logical predictions for a series of phenomena, such as not requiring dark energy in order to give correct predictions for high  $Z$  supernovas. Here, we show that the inclusion of Lorentz relativistic mass has a dramatic impact on the predicted redshift from high gravitational field objects, such as quasars, and stellar objects fitting the mathematical properties of black holes. Taking into account Lorentz relativistic mass provides very different interpretations of quasars and many other objects; for example, it can explain the lack of observed time dilation in quasars. It's possible that, in the past, physicists have simply interpreted observations through a possibly incorrect mathematical lens called general relativity theory.

Incorporating Lorentz relativistic mass likely explains, for example, why high  $Z$  quasars have little or no observed velocity time dilation, something without a good explanation in the standard model.

**Key Words:** gravitational redshift, Lorentz relativistic mass, escape velocity, quasars, black holes, galactic centers

## 1 General Relativity Theory Community Ignored Lorentz Relativistic Mass Without Investigating it Properly

Hendrik Lorentz was awarded the Nobel prize in physics and played a central role in all of relativity theory. When such a prominent researcher has suggested a hypothesis, we expect it to be carefully investigated in relation to its physical predictions, before rejecting it. Lorentz [1] already, in 1899, suggested relativistic mass of the form  $m\gamma$  where  $\gamma$  is the Lorentz factor,  $1/\sqrt{1 - v^2/c^2}$ . Relativistic mass with this form is mentioned in a series of university textbooks in chapters about special relativity theory, but without mentioning that it was invented by Lorentz. Some of these books warn against using relativistic mass.

Einstein, likely unaware of Lorentz' 1899 paper, published two formulas for relativistic mass at the end of his most famous 1905 paper on special relativity theory. Einstein suggested  $m\gamma^2$  as transverse mass and  $m\gamma^3$  as longitudinal mass; neither of them is used today. Einstein has been showing interest in relativistic mass for some years, see [2] but, later on, rejected relativistic mass altogether. Many leading physicists in the general relativity community have been very negative towards relativistic mass; see Adler [3], Okun [4], Taylor and Wheeler [5], Hecht [6]. Some other physicists, including Rindler who is a supporter of special and general relativity, have been much more positive towards relativistic mass; see [7, 8]. Jammer [9] has also been positive towards it. However, neither those negative nor the few positive towards it seem to have investigated what incorporating Lorentz relativistic mass leads to in predictions.

In recent years, the implications of incorporating relativistic mass started to get fully investigated. For example, incorporating Lorentz relativistic mass seems to make worm holes mathematically forbidden [10], which leads to a micro black hole candidate that matches all the aspects of the Planck scale; see [11]. This is something general

relativity theory has not been able to do. Taking into account Lorentz relativistic mass also leads to a somewhat simplified and more logical cosmology [12] that can even be derived from a new quantum gravity theory [13]. Below, we will look at implications for gravitational redshift when incorporating Lorentz relativistic mass.

## 2 Lorentz Relativistic Mass, Escape Velocity, and Escape Radius

The escape velocity in Newton theory is derived by simply solving the following equation with respect to velocity:

$$\frac{1}{2}mv^2 - G\frac{Mm}{R} = 0 \quad (1)$$

which gives

$$v_e = v = \sqrt{\frac{2GM}{R}} \quad (2)$$

This is exactly the same escape velocity one gets from general relativity; see, for example [14]. When we take into account relativistic energy and Lorentz relativistic mass we have:

$$mc^2\gamma - mc^2 - G\frac{Mm}{R} = 0 \quad (3)$$

which gives

$$v_e = v = \sqrt{\frac{2GM}{R} - \frac{G^2M^2}{c^2R^2}} \quad (4)$$

This is what we can call the full relativistic escape velocity; see [12, 15]. We can further solve this for the escape velocity when  $v_e = c$  and this gives:

$$R_h = R = \frac{GM}{c^2} \quad (5)$$

This is half the Schwarzschild radius:  $R_s = \frac{2GM}{c^2}$  that one simply gets by solving the standard escape velocity  $v_e = c = \sqrt{\frac{2GM}{R}}$  for  $R$ . This means super-massive objects like black holes, quasars (that often are considered black holes in the center) and galactic centers that are also considered super-massive black holes, have their mass inside a radius considerably smaller than the Schwarzschild radius. Further, the escape velocity is different than assumed in the standard model. With Lorentz relativistic mass, photons can be sent out from just outside a radius that is half the Schwarzschild radius. Assuming that the inclusion of Lorentz relativistic mass is meaningful, several observations of light sent out from close to the outside of the event horizon of a black hole, are therefore interpreted incorrectly if the mathematical lens of general relativity theory is used. In the next section we will see that this has considerable implications for gravitational redshift and thus for interpretations of the redshift of these objects.

## 3 Background Gravitational Redshift

Light loses energy when leaving a gravitational well; in other words, its wavelength is increased. This is well known as gravitational redshift. Gravitational redshift was likely first predicted by Einstein [16, 17] in 1907 and 1911, but only for a weak field, which basically is given by the formula:

$$\frac{\lambda_\infty}{\lambda_E} = \left(1 + \frac{\Phi}{c^2}\right) \quad (6)$$

where  $\Phi = \frac{GM}{R}$  and  $\lambda_E$  is the emitted wavelength and  $\lambda_\infty$  is the wavelength of the emitted light observed from far away from the gravitational field in question. This formula is identical to the first term in a Taylor series approximation of Einstein's later 1916 formula .

In 1916, Einstein [18] published a gravitational redshift formula that also holds for a strong gravitational field under the assumptions of general relativity theory, and is given by:

$$Z = \frac{\lambda_\infty - \lambda_E}{\lambda_E} = \frac{1}{\sqrt{1 - \frac{2GM}{Rc^2}}} - 1 \quad (7)$$

where  $\lambda_E$  is the emitted wavelength and  $\lambda_\infty$  is the wavelength of the emitted light observed from far away from the gravitational field in question. A high  $z$  means a strong gravitational redshift as observed from far away from the emitted light in the gravitational field.

Einstein's redshift formula is today often also written in the form of the Schwarzschild radius:

$$Z = \frac{\lambda_\infty - \lambda_E}{\lambda_E} = \frac{1}{\sqrt{1 - \frac{R_s}{R}}} - 1 \quad (8)$$

That again can be written in form of escape velocity since  $\frac{v_e^2}{c^2} = \frac{\sqrt{\frac{2GM}{R}}}{c} = \frac{2GM}{Rc^2} = \frac{R_s}{R}$ , so we must also have

$$Z = \frac{\lambda_\infty - \lambda_E}{\lambda_E} = \frac{1}{\sqrt{1 - \frac{v_e^2}{c^2}}} - 1 \quad (9)$$

Gravitational redshift was confirmed in 1959 by the Pound and Rebka [19] experiment where one simply sent a light beam from a tower and measured its wavelength at two different distances from the center of the gravitational field of Earth. The observations were in line with the predictions from general relativity theory. The Pound Rebeka experiment can be seen as a basically direct experiment in which one knew with certainty the distance from which the light is observed relative to the center of the gravitational source. It is, however, important to bear in mind it was a direct experiment in a weak gravitational field. We define a weak gravitational field as that of any redshift experiment performed far away from the radius where the escape velocity is  $c$ ; that is, in general relativity theory, far from the Schwarzschild radius. Gravitational redshift experiments in weak gravitational fields can be easily observed both from the Sun and, in even better controlled experiments, with laser beams on Earth. We know for sure these are very close to what general relativity theory predicts, there is no doubt about that.

Emitted light from very strong gravitational fields can only happen close to the surface (event horizon) of black holes or similar objects. These sources are very far away from us, typically in the center of galaxies and in quasars. These are more indirect observations, as we cannot be 100% sure about what distance to the center of the mass the light has been emitted from. We have observations of the arriving light beam, the interpretation generally being made through a mathematical lens known as general relativity theory as well as the standard cosmological model.

It is not fully clear how to define a strong gravitational field, but here we define it as when we are close to an area of the gravitational object where the escape velocity gets significant relative to  $c$ . The reason we mention this is that a super-massive black hole can have very weak gravitational acceleration close to or at the Schwarzschild radius at the same time as the escape velocity is  $c$  or close to  $c$ .

The gravitational redshift, when taking into account Lorentz relativistic mass, is given by

$$Z = \frac{\lambda - \lambda_E}{\lambda_E} = \frac{1}{\sqrt{1 - \frac{v_e^2}{c^2}}} - 1 = \frac{1}{\sqrt{1 - \frac{2GM}{Rc^2} + \frac{GM}{R^2c^2}}} - 1 \quad (10)$$

The first term of a Taylor series expansion of this formula is  $Z \approx \frac{GM}{c^2 R}$ , which is identical to the well-known weak field approximation in general relativity theory for redshift. This means the two models are practically indistinguishable for predictions of weak gravitational fields, which are the only type of gravitational fields that have been directly measured using all input parameters, such as the radius to the center of the emitting photons. All studies with strong gravitational fields, that is for black hole type objects, are based on a series of assumptions, such as that the Schwarzschild radius is the event horizon radius of the black hole, while it is only half of that when considering Lorentz relativistic mass. Thus, the inclusion of Lorentz relativistic mass, as we shall see, has big implications for the interpretation of observed redshift from such objects.

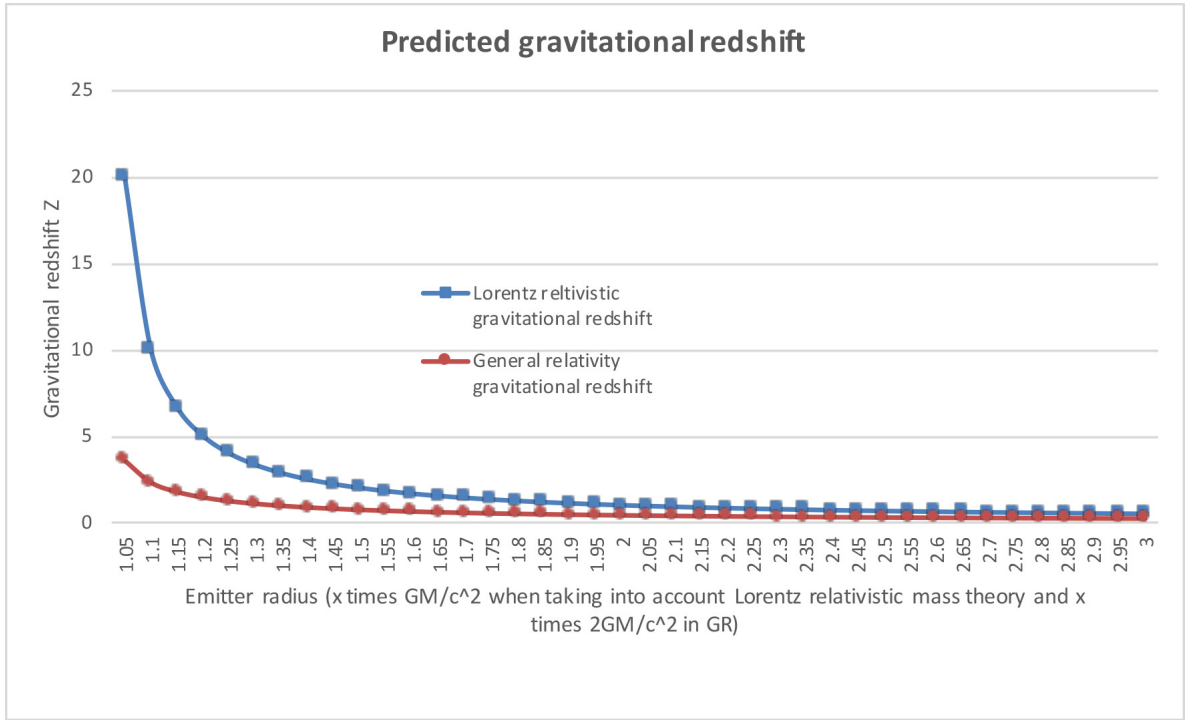
We have simply got the equation (10) by replacing the escape velocity in the standard gravitational redshift formula with the full relativistic escape velocity. This can possibly be seen as a bit heuristic or ad hoc, but one should bear in mind that this is also what has been considered about Einstein's 1907 to 1916 derivation of gravitational redshift; see, for example, Valente [20] who said: "*None of Einstein's redshift derivations qualify as formal derivations; from our perspective, we must consider them as heuristic derivations.*" See also Earman and Glymour [21] who wrote: "*To the modern eye, Einstein's derivation is no derivation at all*". Further, Glymour wrote: "*Einstein's early derivations of the redshift show his most characteristic style of work - heuristic, allusive, sometimes baffling, but unfailingly fruitful.*"

We do not doubt the mathematical correctness of the Einstein gravitational redshift formula, as it was later derived and scrutinized carefully and mathematically. We simply ask the readers also not to hold prejudice against

our formula just presented. It is new<sup>1</sup> and can likely be derived from more profound considerations, or even from a new quantum gravity theory incorporating Lorentz relativistic mass; see [13]. This we will leave for further study.

In a weak gravitational field, as on Earth, or for light emitted from the surface of the Sun or most stars, the predictions from our new redshift formula will be indistinguishable from what is predicted from general relativity; in other words, the above formula is fully consistent with such experiments as the Pound and Rebka experiment or any other weak field gravitational redshift experiment. However, for a strong gravitational field, when the photon has been emitted from close to  $R_h = \frac{GM}{c^2}$  or just close to  $R_s = \frac{2GM}{c^2}$ , then the difference in predictions between the two models will be large.

Figure 1 shows the predicted gravitational redshift from black hole-like objects, that is when the light is emitted from close to the event horizon. General relativity theory predicts the event horizon off by a factor of two since the Schwarzschild is twice the escape radius where  $v_e = c$  with respect to when the Lorentz relativistic mass is assumed. Further, the predicted gravitational red-shift will be strongly underestimated in general relativity theory.



**Figure 1:** The figure shows the predicted gravitational redshift from a blackhole-type mass (quasars and galactic centers). General relativity theory strongly underestimates the gravitational redshift compared to when taking into account Lorentz relativistic mass.

If the inclusion of Lorentz relativistic mass is correct, for black holes, the centers of galaxies or quasars, general relativity will mistakenly predict the event horizon (“surface”) is at the  $\frac{2GM}{c^2}$  and no photons can be sent out closer to the mass than this. Moreover, if the radius where the photons are emitted is all the way down to  $\frac{GM}{c^2}$ , there is typically also a mistake in what distance general relativity predicts the light is emitted from relative to the center of the black hole or the quasar. Through the mathematical lens of general relativity theory, one will therefore misinterpret a series of high  $Z$  gravitational redshifts observed from such objects and attribute much more of the redshift to velocity away from us than is the case if properly accounting for the gravitational redshift.

For example, a black hole (or quasar or center of a galaxy) that in reality is emitting photons from the radius  $1.15R_h = 1.15\frac{GM}{c^2}$ , has a gravitational redshift of  $Z = 6.7$ , as observed far away, according to the model taking into account Lorentz relativistic mass. Instead, general relativity assumes that the photons are sent out from  $1.15 \times R_s = 1.15 \times \frac{2GM}{c^2}$  and predicts a gravitational redshift of only  $Z = 1.77$ . If, for example, this is a quasar and the observed redshift is 7, then in general relativity theory one will mistakenly interpret  $Z = 5.23$  of the observed  $Z = 7$  are due to velocity redshift. One will assume the quasar is traveling fast away from us. On the other hand,

<sup>1</sup>The formula was first presented in our working paper [22].

under our model taking into account Lorentz relativistic mass, only  $Z = 0.3$  is caused by motion of the quasar, while the rest of the observed  $Z$ , that is  $Z = 7 - 0.3 = 6.7$ , is predicted to be caused by gravitational redshift.

If our model is right, it predicts much less velocity time dilation in high  $Z$  quasars than expected from standard theory, and this is exactly what has been found. For example, Hawkings [23, 24], based on large observational studies, has shown that high  $Z$  quasars do not show the strongly expected velocity time dilation that they should according to standard theory, or in the words of Hawkings: “*There does not appear to be a satisfactory explanation for the absence of a time dilation effect in quasar power spectra...*”. The high redshift indicates in the standard model that these high  $Z$  quasars are moving very fast away from us, and therefore they should also have a high velocity time dilation relative to us. This has not been observed. Instead of then saying there is likely something missing in the standard model, it can be conjectured, instead, to formulate a new hypothesis: that these quasars are fast-growing black holes where the lacking time dilation is offset exactly by black hole growth. Nothing can be excluded, but this sounds rather ad hoc.

With our model, the explanation is much simpler. By not taking into account Lorentz relativistic mass, we simply strongly underestimate the gravitational redshift for black hole-like objects, which is what quasars are considered to be. Then we mistakenly conclude that high  $Z$  quasars are moving much faster than they are.

This also means the gravitational redshift from galactic centers is strongly underestimated. In other words, also high  $Z$  galaxies are likely traveling much slower away from us than assumed. Much of observed redshift is likely simply gravitational redshift that can be interpreted as such when taking into account Lorentz relativistic mass.

## 4 Conclusion

General relativity theory correctly predicts gravitational redshift in weak gravitational fields. For strong gravitational fields, general relativity theory strongly underestimates the gravitational redshift if Lorentz relativistic mass is relevant. The inclusion of Lorentz relativistic mass can explain the lacking velocity time dilation in high  $Z$  quasars. This also gives a new perspective on a series of things related to interpretation of galactic redshifts, as galaxies have very strong gravitational fields close to the center as they are considered to be black holes. Taking into account Lorentz relativistic mass predicts much higher gravitational redshift, indicating that many galaxies are likely not traveling away from us as fast as assumed.

This result falls nicely in line with a series of other recent studies looking at effects resulting from the incorporation of Lorentz relativistic mass: micro black holes are suddenly fully consistent with the Planck scale, something not foreseen by general relativity theory. Further, the inclusion of Lorentz relativistic mass predicts supernovas in almost perfect line with observations without the need of dark energy, and one also gets a simpler cosmological model than the Friedmann [25] model, both mathematically and logically. Additionally, worm holes seem to be mathematically forbidden when incorporating Lorentz relativistic mass.

## References

- [1] H. A. Lorentz. Simplified theory of electrical and optical phenomena in moving systems. *Proc. Acad. Scientific, Amsterdam*, 1:427, 1899.
- [2] A. Einstein. On a method for the determination of the ratio of the transverse and longitudinal mass of the electron. *Annalen der Physik*, 21:583, 1906.
- [3] C. G. Adler. Dose mass really depends on velocity dad? *American Journal of Physics*, 55:739, 1987. URL <https://doi.org/10.1119/1.15314>.
- [4] L. B. Okun. The concept of mass. *Physics Today*, 42, 1989. URL <https://doi.org/10.1063/1.881171>.
- [5] E. F. Taylor and J. A. Wheeler. *Spacetime Physics, Introduction To Special Relativity*. W. H. Freeman and Company, New York, 1992.
- [6] E. Hecht. Einstein never approved the relativistic mass formula. *The Physics Teacher*, 47:336, 2009. URL <https://doi.org/10.1119/1.3204111>.
- [7] W. Rindler. Putting to rest mass misconceptions. *Physics Today*, 43:13, 1990. URL <https://doi.org/10.1063/1.2810555>.
- [8] Wolfgang Rindler. *Relativity, Special, General and Cosmology, Second Edition*. Oxford University Press, 2006.

- [9] M. Jammer. *Concepts of Mass in Contemporary Physics and Philosophy*. Princeton University Press, 2000.
- [10] E. G. Haug. Wormholes do not exist, they are mathematical artifacts from an incomplete gravitational theory (?). *Journal of High Energy Physics, Gravitation and Cosmology*, 8:517, 2022. URL <https://doi.org/10.4236/jhepgc.2022.83037>.
- [11] E. G. Haug and G. Spavieri. Micro black hole candidates and the planck scale. *Research Gate, Under Review*, 2022.
- [12] E. G. Haug. A new full relativistic escape velocity and a new hubble related equation for the universe. *Physics Essays*, 34(4):502, 2021. URL <http://dx.doi.org/10.4006/0836-1398-34.4.502>.
- [13] E. G. Haug. Unified quantum gravity field equation describing the universe from the smallest to the cosmological scales. *Physics Essays*, 35:61, 2022. URL <https://doi.org/10.4006/0836-1398-35.1.61>.
- [14] A. T. Augousti and A. Radosz. An observation on the congruence of the escape velocity in classical mechanics and general relativity in a schwarzschild metric. *European Journal of Physics*, 376:331–335, 2006. URL <https://doi.org/10.1088/0143-0807/27/2/015>.
- [15] J. A. Rybczyk. Relativistic escape velocity using relativistic forms of potential and kinetic energy. *Working paper*, 2009.
- [16] A. Einstein. On the relativity principle and the conclusions drawn from it. *Jarbuch der Radioaktivität und Elektronik*, 4:411, 1907.
- [17] A. Einstein. Über den einfluss der schwercraft auf die ausbreitung des lichtes. *Annalen der Physik*, 340:898, 1911. URL <https://doi.org/10.1002/andp.19113401005>.
- [18] A. Einstein. Die grundlage der allgemeinen relativitätstheorie. *Annalen der Physics*, 354:769, 1916. URL <https://doi.org/10.1002/andp.19163540702>.
- [19] R. V. Pound and G. A. Rebka Jr. Gravitational red-shift in nuclear resonance. *Physical Review Letters*, 3(9): 439–441, 1959. URL <https://journals.aps.org/prl/pdf/10.1103/PhysRevLett.3.439>.
- [20] M. B. Valente. Einstein’s redshift derivations: its history from 1907 to 1921. *Circumscribere*, 22:1, 2018. URL <https://doi.org/10.23925/1980-7651.2018v22;1-16>.
- [21] J. Earman and C. Glymour. The gravitational red shift as a test of general relativity: History and analysis. *Studies in History and Philosophy of Science Part A*, 11:175, 1980. URL [https://doi.org/10.1016/0039-3681\(80\)90025-4](https://doi.org/10.1016/0039-3681(80)90025-4).
- [22] E. G. Haug. Planck length, planck time and speed of gravity when taking into account relativistic mass with no knowledge of  $g$ ,  $h$  or  $c$ . *Hal archive*, 2022. URL <https://hal.archives-ouvertes.fr/hal-03669505/document>.
- [23] M. R. S. Hawkins. On time dilation in quasar light curves. *Mon. Not. R. Astron. Soc.*, 406:1047–1054, 2000. URL <https://doi.org/10.1111/j.1365-2966.2010.16581.x>.
- [24] M. R. S. Hawkins. Time dilation and quasar variability. *The Astrophysical Journal*, 553:97–100, 2001. URL <https://doi.org/10.1086/320683>.
- [25] A. Friedmann. Über die krüung des raumes. *Zeitschrift für Physik*, 10:377, 1922. URL <https://doi.org/10.1007/BF01332580>.