Robust Understanding of Gravitational Redshift

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Abstract. In the early 20th century, a lack of understanding of the physical mechanism of gravity led to erroneous assumptions. In 2020, a new physical paradigm that uses only one entity to describe the world of the masses was published. That work, seven additional publications, and two videos have together clarified and illustrated the true causes of many physical phenomena including gravity, dark matter, dark energy, and electric charge.
Here, we continue to reexamine physics assumptions in light of the new paradigm.

Key words: equivalence principle, time dilation, new paradigm, gravity.

1. Introduction

In the 1960s, Pound, Rebka, and Snider (1960, 1964) performed redshift experiments whose results led to two interpretations: either (1) photons become redshifted when moving upward or (2) their frequency does not change, but the atoms at the bottom are redshifted with respect to those at the top.

In the 20th century, physicists did not understand how gravity works, and no model of the photon was available. This lack of knowledge prevented the problem of photons' movement in a gravitational field from being solved.

Einstein came up with the idea of identifying being in a gravitational field with being in an accelerating elevator while the difference between the two was unknown [1]:

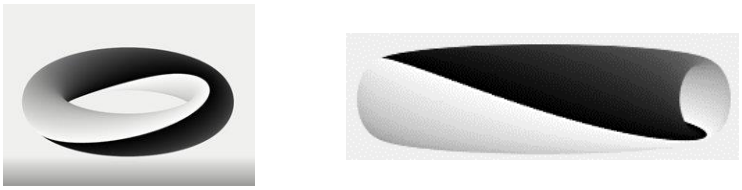
"we ... assume the complete physical equivalence of a gravitational field and a corresponding acceleration of the reference system."

Thus, the complex problem could be replaced with a simple problem involving the movement of ball-like photons in an elevator.

Although Einstein's assumption was erroneous, overall, the equivalence principle played a positive role in physics, by stimulating testing and debate. However, this principle continues to dominate, thus hindering progress in physics. After more than 100 years, Wikipedia does not indicate a conclusive answer regarding the cause of gravitational redshift [2].

2. The new physical paradigm

In 2020, the publication of a new paradigm [3] led to a breakthrough in understanding gravity [4]. The new paradigm is based on Tesla's primary substance. Elementary particles and atoms are vortices of primary substance (Fig. 1).



a) b)

Fig. 1. Elementary particles and atoms are stable vortices of primary substance: a) an electron vortex; b) a photon. The photon has a toroidal shape similar to that of an electron but is highly elongated.

The primary substance not only is the universal building material for mass creation but also is the universal medium. When its density is non-uniform, it is a gravitational field.

The new paradigm enables robust understanding of physical phenomena by revealing their true causes. The publication of the new paradigm provided new opportunities to reconsider phenomena from a new viewpoint. Here, we consider interpretations of gravitational redshift to provide new insights.

According to the presented model, a photon is a stretched toroid, along which a density wave of primary substance circulates. The wave closes on itself, and a cycle is formed.

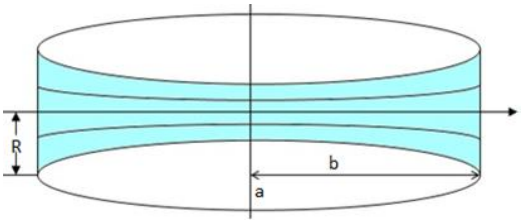


Fig. 2. Cross-section of a photon in free flight, according to its proportions (from reference [3]).

3. Heuristic equivalence principle

The first interpretation of the gravitational redshift was based on Einstein's equivalence principle [5]. The equivalence principle of general relativity requires all test masses to accelerate equally in a gravitational field, independently of their composition.

The new paradigm reveals the mechanism of free fall acceleration [6].

The speed of the density wave depends on the density of the medium through which the wave passes: a higher medium density corresponds to a lower density wave speed, and vice versa. Consequently, in a gravitational field, the density wave speed rotates (Fig. 3).

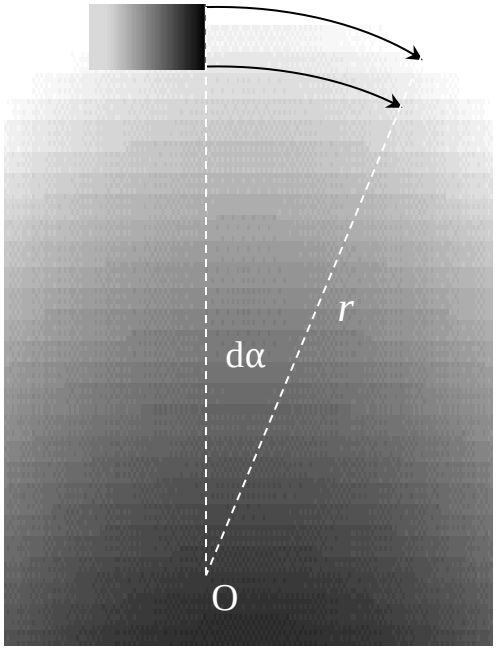


Fig. 3. A density wave deviates in a gravitational field because of a difference in the wave velocity at the edges.

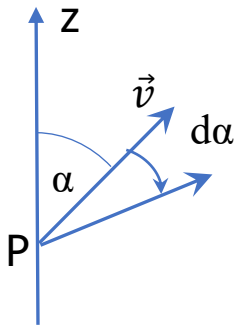


Fig. 4. Change in the vertical velocity component for point P on the wave front of a particle-vortex during free fall.

In reference [7], the angle $d\alpha$ of rotation of the density wave in a gravitational field is derived as follows:

$$d\alpha = \nabla u \sin \alpha \, dt \qquad (1)$$

where u is the wave speed in free space, and α is the angle between $\nabla \mathrm{u}$ and the direction of the wave velocity $\vec{v}$ inside the photon (Fig. 4). The rotation occurs in the plane parallel to $\nabla \mathrm{u}$ and $\vec{v}$.

Each point on the photon wave front moves along the trajectory of an "elongated cycloid" (Fig. 5).

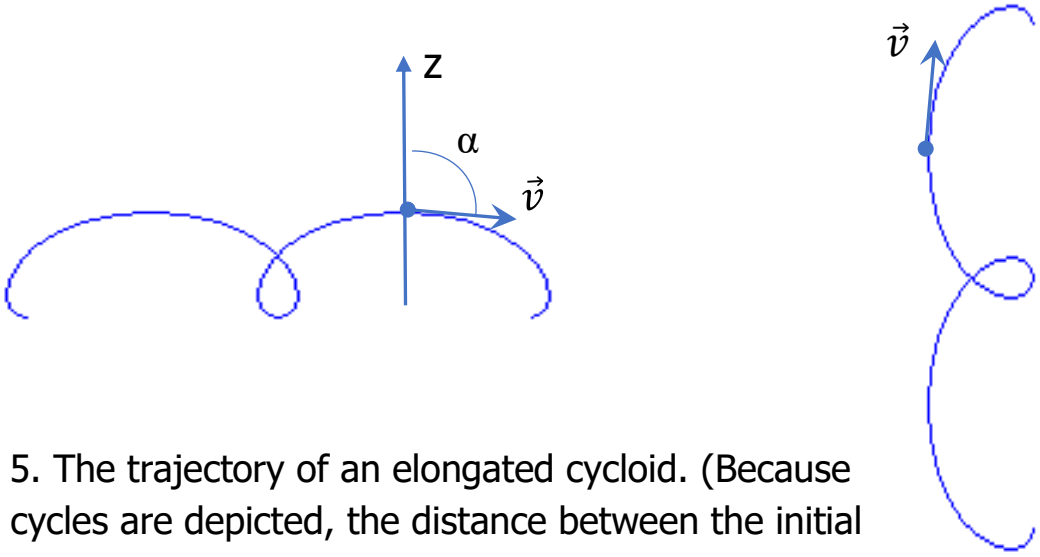


Fig. 5. The trajectory of an elongated cycloid. (Because two cycles are depicted, the distance between the initial and final points of the trajectory is 2λ.)

When a photon moves horizontally, its density wave speed is predominantly horizontal, and the angle α is close to $\pi/2$ (Fig. 5, left). According to equation (1), in this case, the downward deviation of the density wave and its gravitational acceleration are maximal [6].

In the case of vertical photon motion, the angle α is close to zero (Fig. 5, right). Therefore, the gravitational acceleration of the photon is close to zero.

Thus, for a photon, gravitational acceleration dramatically differs for horizontal and vertical motion. In contrast, the equivalence principle requires all objects in the gravitational field to have the same acceleration.

Thus, we can conclude that the equivalence principle is wrong. In addition, reference [8] has shown that fast-moving test bodies violate the equivalence principle.

Hence, the interpretation of the gravitational redshift based on the equivalence principle is also incorrect.

4. Simplistic interpretation of gravitational redshift

Many publications have described the simplified interpretation of redshift. According to this interpretation, photons lose energy when moving upward (Wikipedia [2]).

> "In physics and general relativity, gravitational redshift … is the phenomenon that electromagnetic waves or photons travelling out of a gravitational well (seem to) lose energy."

In 2000, Okun, Selivanov, and Telegdi conducted an educational campaign against this interpretation, calling it naive [9]:

> "The phenomenon of gravitational redshift is widely explained by using (explicitly or implicitly) a presumed analogy between a photon and a stone: when moving away from a gravitating body (sun or earth) both a photon and a stone are supposed to lose energy overcoming the gravitational attraction."

Okun et al. [9] have explained that, although a stone loses its energy when overcoming the gravitational attraction, the analogy between a photon and a stone is incorrect: the energy of a photon remains unchanged.

Applying this analogy is akin to applying the formula for the movement of a stone to the flight of a bird.

The new paradigm reveals the physical mechanisms of the phenomenon and thereby refutes the erroneous interpretation.

The next section presents the derivation of the frequency of a photon moving upward in a gravitational field.

5. Essential relation between mass and space

The dominant paradigm does not define mass and space [10].

> "Space is one of the few fundamental quantities in physics, meaning that it cannot be defined via other quantities because nothing more fundamental is known at the present."

In the new paradigm, mass and space are opposite properties of the same entity, similarly to heat and cold. Mass is compressed space. Mass and space are inversely proportional [3].

Let ρ denote the density of unorganized primary substance. Because mass and space are inversely proportional, distances d in the space are $\sim 1/\rho$. Let u be the component of the density wave speed perpendicular to the photon velocity $\vec{c}$ (Fig. 6).

$u = d/t \sim 1/\rho$, where t is the time to travel distance d.

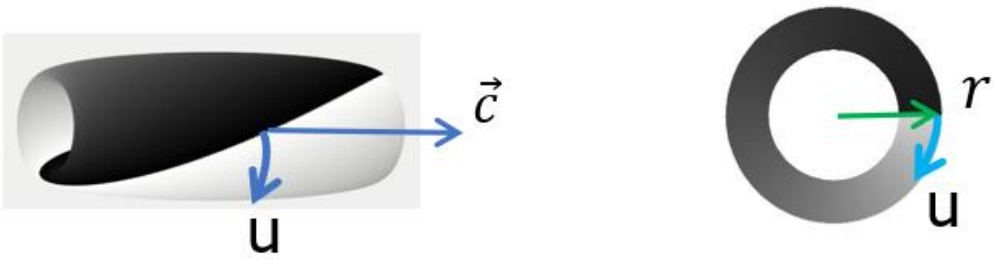


Fig. 6. The two components of the wave front velocity (left) and the photon's cross-section perpendicular to its velocity $\vec{c}$ (right).

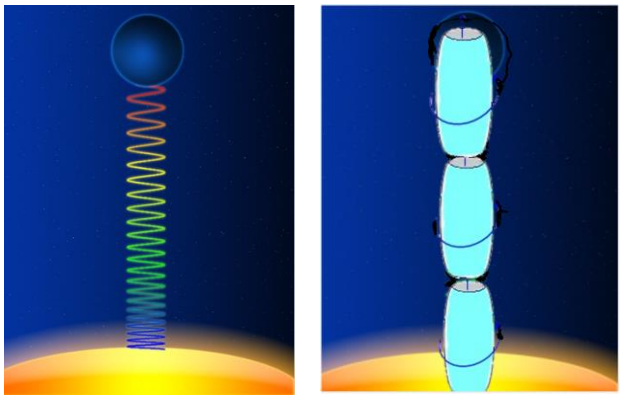
Photon radius r is also a distance; therefore, $r \sim 1/\rho$, and the photon frequency $\omega = u/r$ remains unchanged.

$$\rho \begin{cases} \nearrow\ d \sim 1/\rho;\ r \sim 1/\rho \\ \searrow\ \mathrm{u} \sim 1/\rho \end{cases} \Rightarrow \omega = \frac{u}{r} = const \qquad (2)$$

Thus,

> The frequency of photons does not change as they rise in the gravitational field.

Wikipedia has a beautiful but wrong illustration of the gravitational redshift [2] suggesting a photon's frequency decreases as the photon rises in the gravitational field (Fig. 7, left).



a) b)

Fig. 7. Two illustrations of a photon moving upward in a gravitational field: a) wrong illustration; b) corrected illustration.

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If different photons are at the same location, all have the same density wave speed u, and the photon frequency is inversely proportional to its size $\omega_i = u/r_i \sim 1/r_i$: the smaller a photon's size, the higher its frequency.

This relationship is illustrated in Fig. 8: because the blue photons are smaller than the red photons, their frequency is higher.

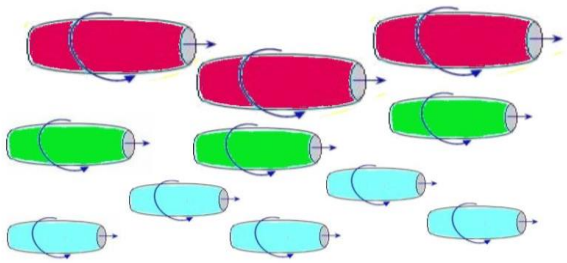

Fig. 8. Illustration of the relationship between photon size and color, i.e., the rotational frequency of the photon.

The energy of visible light photons is approximately 3 eV. The energy of X-ray photons used in medicine is 25,000 times greater.

Hence, X-ray photons are 25,000 times smaller than visible light photons and can penetrate soft tissue, whereas visible light photons are trapped.

6. The strange concept of gravitational time dilation

Let us explore the exact meaning of the expression "gravitational time dilation" through examples of its use.

"In a strong gravitational field, the clocks run more slowly." Thus, the following question arises: do absolutely all or only some clocks slow down in such a field? As a counter example, a pendulum clock has a period of oscillation $T = 2\pi\sqrt{\frac{l}{g}}$. At low altitudes, where g is greater, the period of oscillation T is shorter, and the frequency increases; therefore, the pendulum oscillations accelerate.

Consequently, not all clocks are slowing down, and the situation is not as global as its name might suggest.

Time is determined by comparison with a standard [11]. Any standard can change and then cease to be the standard. For example, although

heating of a meter standard leads to its lengthening, this heating does not expand the space.
One will not affirm that space expansion occurs in hot weather merely because the fact that metal rulers lengthen when heated (Fig. 9).

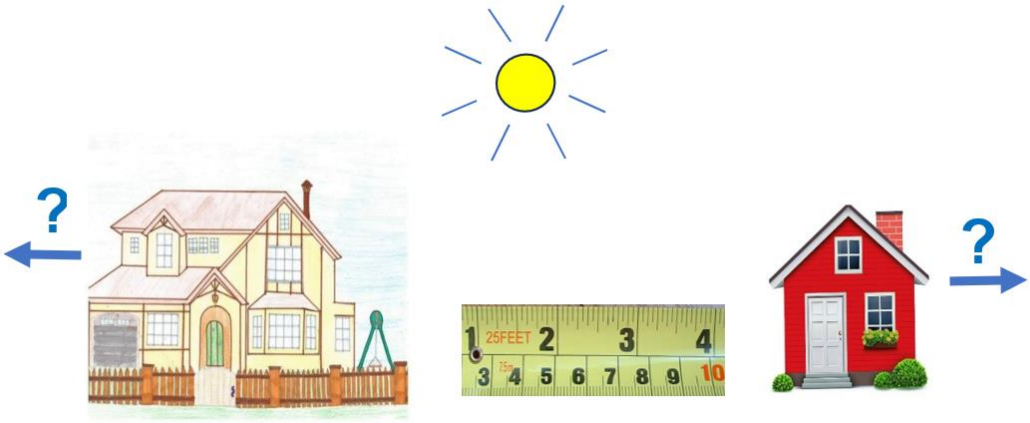

Fig. 9. Wrong conclusion that space expansion occurs in hot weather.

Any number of incorrect clocks will not be able to slow time. Substitution of the vague term "gravitational time dilation" by "slowing down the atomic clocks" would avoid this misconception. Consequently, it becomes clear that one must only adjust the faulty clocks.

The term "gravitational time dilation" is misleading because it is unrelated to time. This example indicates how misuse of words can hinder understanding.

7. The frequency of an atom's radiation depends on the medium density

The previous section concluded that "gravitational time dilation" essentially means slowing of the speed of a density wave in a strong gravitational field. Consequently, in lowlands, the density waves in particles and atoms slow, and the atoms emit photons at a lower frequency.

For spherically symmetric gravitational field, we use Broekaert's formula [12]

$$u(R) = u_0 \exp(-2\kappa/R), \qquad (3)$$

where u_0 is the velocity of a density wave far from gravitational fields, R is the distance to the center of the gravitating body, and κ is half the Schwarzschild radius.

The question arises as to why atoms in the lowlands do not compress as photons do. The answer is that photons in flight are "blown through" by the primary substance of the medium and "feel" the change in the density of the medium throughout their entire volume.

In contrast, atoms are weakly dependent on the environment, because their nuclei maintain a high density of primary substance inside the atom (electric charge interpretation in [13]). The situation is akin to a hot object placed in a cold place. If the object contains an internal heater, then the object will not take on the ambient temperature.

Therefore, unlike a "blown through" photon, the size of an atom does not depend on the density of the surrounding medium. Hence, the frequency of emission/absorption of an atom is proportional to the speed of the density wave $\nu \sim u$.

Consequently, "reddening" of the atom occurs when it descends in a gravitational field (Fig. 10, left).

Gravitational redshift occurs not because a photon rises in the gravitational field but because it is emitted by a redshifted atom (Fig. 10).

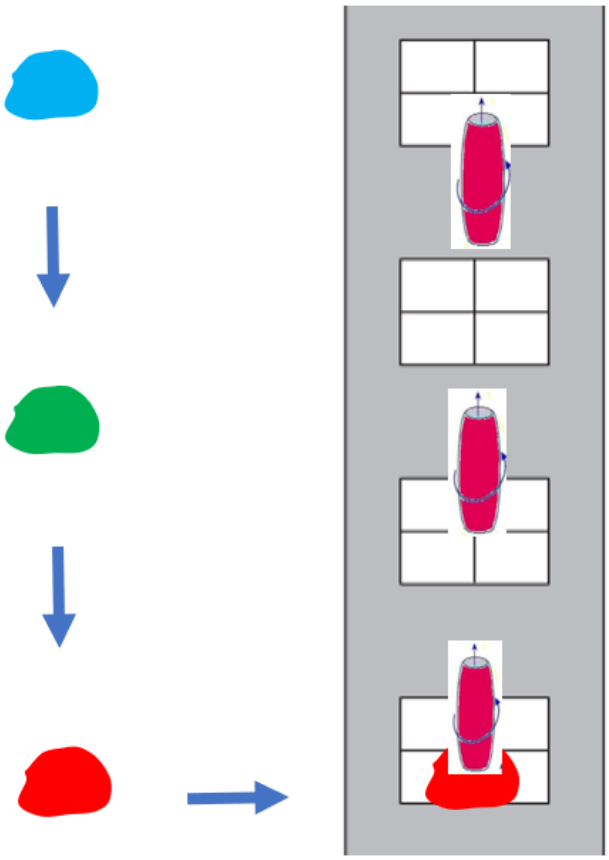

Fig. 10. An atom "reddening" as it descends in a gravitational field. The frequency of an ascending photon does not change.

This effect was confirmed by the Global Positioning System in 1996 [14].

Conclusion

In this work, the heuristic interpretations of gravity and photons were replaced by a robust understanding of these phenomena.

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