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Is Photon Frequency Immutable?

Abstract

Gravitational redshift is currently believed to be the result of the loss of energy of photons as they emerge from a gravitational field into a field of lesser strength. Conversely, gravitational blueshift is believed to be the result of an increase in energy of photons as they move into a gravitational field from a field of lesser strength. Cosmological redshift is believed to be the result of the loss of energy of photons as they travel cosmological distances through an expanding space.

I will argue that gravitational redshift is caused by time dilation of the source of radiation at the gravitational body. The redshift of the photons emitted by the source account in full for the measurement of redshift of those photons in a lesser gravitational field. The obverse works for the measurement of gravitational blueshift. The wavelength of the photons received in a stronger gravitational field is measured to be shorter than the emitted wavelength because of time dilation of the receiver. The measured blueshift is illusory and is a measurement artifact. Neither gravitational redshift nor gravitational blueshift results from changes in photon frequency. The frequency of a photon is not changed as the photon moves within a gravitational field to either a weaker or a stronger field.

The inherent frequency of a photon is the frequency at which the photon was emitted. The apparent decrease in frequency of the photon in the cosmological redshift results from the increased wavelength that is, in turn, the result of the expansion of space during the photon's journey, not the result of a decrease in the inherent frequency of the photon. The effect is akin to the Doppler shift caused by the observer's recessional velocity from the source of radiation.

The conclusion: Photon frequency is immutable.

Table of Contents

List of Tables

1.0 First Matters

> ‘Once it became accepted that light was an electromagnetic wave, it was clear that the frequency of light should not change from place to place, since waves from a source with a fixed frequency keep the same frequency everywhere. One way around this conclusion would be if time itself were altered—if clocks at different points had different rates.’ [4]

1.1 Objectives of this Study

Table 1. Objectives of this Study
Show that the frequency of a photon is not changed as the photon moves within a gravitational field to a weaker field.
Show that gravitational redshift is caused by time dilation of the source of radiation at the gravitational body.
Show that the frequency of a photon is not changed as the photon moves within a gravitational field to a stronger field.
Show that gravitational blueshift is caused by time dilation of the receiver within a gravitational field. The measured blueshift is illusory and an artifact of the measurement itself.
Show that cosmic expansion does not change the frequency of a photon as it journeys through space and time.
Show that photons are not directly subject to gravity.
Conclude that photon frequency is immutable.

1.2 Definition of a Process

A process is any sequence of events that takes time. A process could be subatomic, molecular, chemical, mechanical or biological.

> 'All processes—chemical, biological, measuring apparatus functioning, human perception involving the eye and brain, the communication of force—everything, is constrained by the speed of light. There is a clock functioning at every level, dependent on light speed and the inherent delay at even the atomic level. Biological aging, therefore, is in no way different from clock time-keeping.'
>
> Taylor and Wheeler [11]

1.3 Measurements of Redshift and Blueshift

The emission or absorption spectrum of light from a star or galaxy is compared with a known source using a spectroscope. The emission spectrum from a star or galaxy comprises the sum of spectra from the excited atoms radiating light from the star's surface and atmosphere. The known source comprises the spectra of one or more species of excited atoms superimposed on the spectrum from the star. The spectra of the known source provide benchmarks that enable any difference in wavelength of the stellar spectra to be determined.

The frequency distribution of the pattern of emission lines in the stellar spectra identifies the atoms. If the frequency of the pattern of lines is lower than that of the known pattern of given elements the frequency is redshifted; if higher, the frequency is blueshifted.

2.0 The Temporal Inertial (TI) Field Model of Gravity and Inertia

See Appendix A for a description of the properties of the TI field applicable to this study.

The three properties of the TI field model that are most important to this study are listed below. These properties have been derived from previous studies. [6] [7]

1. The TI field is subject to gravity.
2. The velocity of a photon is c relative to the TI field.
3. Photons are not directly subject to gravity.

If the first two items in this list are true, then Item 3 must also be true, but I'll argue its validity without its presumption in the following sections.

I term the frequency of a photon at emission as the inherent frequency of the photon. The thesis of this paper is that the frequency of a photon is immutable; its inherent frequency does not change regardless of its motion or the presence or absence of a gravitational field. This notion is apparently contradicted by measurements of gravitational redshift, gravitational blueshift and cosmological redshift.

- I'll show that these measurements derive from the motion of the TI field relative to the source of the emission and/or motion of the TI field relative to the observer.
- I'll show that the gravitational effects are caused by differences in the time dilation of the emitter and/or receiver, not by changes in the inherent frequency or frequencies of the measured photons.

3.0 Gravitational Redshift

Table 2. Gravitational Redshift
The Source of Radiation
The typical source of radiation in measurements of redshift is the light from a star or galaxy or even a cluster of galaxies. The ultimate source is, of course, light from stars. This light is characterized by the emission spectrum from the stars, the absorption spectrum from the stars or a combination of both.
The emission spectrum from a star or galaxy comprises the sum of spectra from the excited atoms radiating light from the star's surface and atmosphere.
The absorption spectrum from a star results from the absorption of photons by the atmosphere of the star. The spectrum consists of dark lines that, like an emission spectrum, identify the atom or molecule responsible for the absorption.
Time Dilation Effect
Time dilation in the gravitational field of the star slows all processes in the field producing redshift of the light emanating from the star.
See Section B.2 in Appendix B in which I attribute time dilation in a gravitational field to the infall velocity of the TI field.
The infall velocity of the TI field at the emitter (e.g., a star) is greater than at the receiver. The infall velocity of the TI field is the negative of the escape velocity from the star as described in Section B.6.
The emitter runs slow by the factor shown in Eq (B-2) because of time dilation caused by the infall velocity of the TI field.
The emitted photons are redshifted by the factor shown in Eq (B-4) because of the time dilation of the emitter. This is a real redshift.
The wavelength of photons at the receiver ***is measured to be*** the same as at the emitter. The photons have been redshifted at the emitter.

Table 2. Gravitational Redshift
Velocity Effect
The infall velocity of the TI field is less at the receiver than at the emitter.
In moving from the emitter to the receiver, the photons' velocity relative to the receiver increases. This increases the wavelength of the photons.
At the receiver, the increase in wavelength of the photons is compensated by the increase in their velocity relative to the receiver. This is real redshift, but is undetectable by the receiver because the photons move faster past the receiver in the same ratio as their increase in wavelength.
This redshift is attributable to the change in velocity of the TI field between the source and the receiver, not to a change in the inherent frequency of the photons.
Summary
The redshift caused by time dilation of the emitter is detected at the receiver.
The redshift caused by the difference in velocity of the photons between the emitter and receiver is a real redshift, but is undetectable by the receiver.
The inherent frequency of the photons at emission is not changed as they climb out of the gravitational well of the GB because they propagate at the velocity of c relative to the TI field.
If photons were directly subject to gravity they would experience additional redshift as they climbed out of the gravitational well of the GB. The amount of this redshift would be the same magnitude as that caused by time dilation of the emitter. Accordingly, the measured redshift would be double that measured in the real world. Hence photons are not directly subject to gravity.
The inherent frequency of photons in this interaction with the effects of gravity is immutable.

4.0 Gravitational Blueshift

Table 3. Gravitational Blueshift
Time Dilation Effect
The infall velocity of the TI field at the receiver is greater than at the emitter. The infall velocity of the TI field is the negative of the escape velocity from the star as described in Section B.6.
The receiver runs slow by the factor shown in Eq (B-2) because of time dilation caused by the infall velocity of the TI field.
Time dilation at the receiver slows all processes in the receiver producing redshift of the emission lines used to compare with the photons to be measured.
The wavelength of the received photons is measured to be shorter than the emitted wavelength because of time dilation of the receiver. The measured blueshift is illusory and is a measurement artifact.
Velocity Effect
The infall velocity of the TI field is greater at the receiver than at the emitter.
In moving from the emitter to the receiver, the photons' velocity relative to the receiver increases. This increases the wavelength of the photons. This redshift of the photons is real.
At the receiver, the increase in wavelength of the photons is compensated by the increase in their velocity relative to the receiver. This real redshift is undetectable by the receiver because the photons move faster past the receiver in the same ratio as their increase in wavelength.
This real redshift is attributable to the change in velocity of the TI field between the source and the receiver, not to a change in the inherent frequency of the photons.
Summary
The measured blueshift caused by time dilation of the receiver is illusory and is a measurement artifact.
The redshift caused by the difference in velocity of the photons between the emitter and receiver is a real redshift, but is undetectable by the receiver.
The inherent frequency of the photons at emission is not changed as they descend into the gravitational well of the GB because they propagate at the velocity c relative to the TI field.

Table 3. Gravitational Blueshift
If photons were directly subject to gravity they would experience real blueshift as they descended into the gravitational well of the GB. The amount of this blueshift would be the same magnitude as that caused by time dilation of the receiver. Accordingly, the measured blueshift would be double that measured in the real world. Hence photons are not directly subject to gravity.
The inherent frequency of photons in this interaction with the effects of gravity is immutable.

5.0 Cosmological Redshift [1] [9]

Table 4. Cosmological Redshift
Divide the space from here to a distant galaxy into tiny sections.
If space is isotropic and homogeneous, each section expands at the same rate as every other section.
From the perspective of a given point in space, every other point in space is accelerating away.
A photon moving anywhere in space moves into a section that is moving a tiny bit faster than the one just behind the photon in space and time.
The photon moves a little farther in each successive time interval than in the previous time interval.
The leading edge of the waveform of a photon moving through this space is accelerated at a greater rate than the trailing edge, thus increasing the wavelength of the photon.
The increase in wavelength of the photon is proportional to the increase in the expansion of space over the same interval traversed by the photon.
Are these assertions valid if different sections through which the photon passed expanded at different rates at different times? As the photon moved from the distant galaxy to us, it traversed different 'time zones' during which the expansion rate of the Universe may have changed. It didn't matter to the photon, its change in wavelength was proportional to the change in size of the Universe at the time the photon passed through that section of the Universe at that time.

Table 4. Cosmological Redshift
At the end of a long journey the change in the wavelength of the photon is the sum of all those little changes in wavelength each of which was proportional to the change in size of the Universe during the period that the photon moved from one section to another. Accordingly, the total change in wavelength of the photon is proportional to the change in size of the Universe during the photon's journey.
The cosmic scale factor, a, is a measure of the expansion of the Universe.
During the photon's journey the relative change in size of the Universe increased from a_{then} to a_{now}.
During the photon's journey the wavelength of the photon increased in proportion to the increase in linear dimension of the Universe. $$\lambda_{now} / \lambda_{then} = a_{now} / a_{then} \qquad (1)$$
The inherent frequency of the photon is the frequency at which the photon was emitted. The apparent decrease in frequency of the photon results from the increased wavelength that is, in turn, the result of the expansion of space during the photon's journey, not the result of a decrease in the inherent frequency of the photon. The effect is akin to the Doppler shift caused by the observer's recessional velocity from the source of radiation.
If this description of the cause of cosmological redshift is accepted, then there can be no other contribution to the redshift of the photon. This eliminates any change in the inherent frequency of the photon, the frequency at which it was emitted.
This explanation for cosmological redshift supports the assertion that the inherent frequency of a photon is immutable.

6.0 Conclusions

Table 5. Conclusions
Conclusions from the Properties of Photons
The velocity of a photon is c relative to the space that it is in. That space is the TI field.
Photons are not directly subject to gravity.
Given A and B, photon frequency is immutable.
Conclusions from Gravitational Redshift
Gravitational redshift is caused by time dilation of the source of radiation at the gravitational body. This real redshift is measured by the receiver.
Photon energy does not decrease as a photon radiates away from a gravitational body.
The infall velocity of the TI field at the receiver far from the gravitational field is less than at the emitter and thus has two effects: 1) the wavelengths of photons moving past the receiver are increased and 2) the photons move faster in the same ratio as the increase in their wavelength, hence their true ***redshift*** is undetectable by the receiver.
This redshift is attributable to the change in velocity of the TI field between the source and the receiver, not to a change in the inherent frequency of the photons.
Gravitational redshift does not change the inherent frequency of photons.
Conclusions from Gravitational Blueshift
Gravitational blueshift is caused by time dilation of the receiver within a gravitational field. The measured blueshift is illusory and an artifact of the measurement itself.
The infall velocity of the TI field at the receiver is greater than at the emitter and has two effects: 1) the wavelengths of photons within the TI field are increased and 2) the photons move faster in the same ratio as the increase in their wavelength, hence their true ***redshift*** is undetectable by the receiver.
This true redshift is attributable to the change in velocity of the TI field between the source and the receiver, not to a change in the inherent frequency of the photons.

Table 5. Conclusions
Gravitational blueshift does not change the inherent frequency of photons.
Conclusions from Cosmological Redshift
The inherent frequency of the photon is the frequency at which the photon was emitted. The apparent decrease in frequency of the photon in the cosmological redshift results from the increased wavelength that is, in turn, the result of the expansion of space during the photon's journey, not the result of a decrease in the inherent frequency of the photon. The effect is akin to the Doppler shift caused by the observer's recessional velocity from the source of radiation.
Cosmological redshift does not change the inherent frequency of photons.
Summary of Conclusions
Gravitational redshift and gravitational blueshift are both caused by time dilation of either the emitter of photons or the receiver.
Neither gravitational redshift nor gravitational blueshift results from changes in photon frequency. The frequency of a photon is not changed as the photon moves within a gravitational field to either a weaker or a stronger field.
Cosmological redshift does not change the inherent frequency of photons.
The frequency of a photon is immutable.
Photons are not directly subject to gravity.
If a photon's frequency is immutable, then photon energy does not decrease as a photon radiates away from a gravitational body.
If a photon's frequency is immutable, then photon energy does not increase as a photon moves from a weak gravitational field to a stronger one.
The immutability of photon frequency means that no energy is lost by a photon in its journey through the Universe. The energy of the photon is thus conserved.

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Appendix A

Properties of the Temporal Inertial (TI) Field

Previous studies have described the effects of gravity on the TI field. [6] [7] These effects are summarized in Table A.1. [2] [10]

Table A.1 Effects of Gravity on the TI Field
The TI field is a field of particles that participates in the inertial and gravitational interactions.
The TI field supports the propagation of nature's force particles.
The velocity of a photon is c relative to the TI field.
The TI field is subject to gravity.
Photons are not directly subject to gravity.
Particles of the TI field are accelerated by gravity (in accord with Eq (B-1) directly toward the center of each gravitational body (GB) just as test particles would be and reach the escape velocity of such particles at the distance of those particles from the gravitational center of the GB.
The one and only cause of time dilation of a process is the velocity of the process relative to the TI field.
A gravitational field affects the time dilation of a process within the field only through the mediation of the TI field. A gravitational body accelerates the TI field toward the body. The infall velocity of the TI field at a process within the gravitational field is the direct cause of time dilation of the process in accord with Eq (B-2).
An example of time dilation of a process is the emission of photons by an atom within a gravitational field. Time dilation slows the internal clock of the atom affecting the emission spectrum of the atom. The emission spectrum of an atom within a gravitational field is redshifted relative to the spectrum of that atom within a weaker gravitational field.

Appendix B

Time Dilation and Redshift Formulas [8] [12]

B.1 The Acceleration Profile About a Gravitational Body [6]

The acceleration profile about a GB is given by Eq (B-1). The acceleration profile expresses the acceleration that a small test object would experience if placed at a distance r from the GB.

$$a = G\ M_{act}\ /\ r^2 \qquad \text{(B-1)}$$

where

a is the acceleration of a test object toward the GB at a distance r from the GB.

G is the universal gravitational constant.

M_{act} is the active gravitational mass of the GB.

r is the distance between the GB and the point at which the acceleration is measured.

B.2 Time Dilation as a Function of Velocity Relative to the TI Field

Equation (B-2) shows that the period of a clock is a function of the difference in velocity between the clock and the TI field. The greater this difference in velocity the greater is the period of the clock.

In this equation the test clock is stationary relative to the GB, but the infall velocity of the TI field at the test clock is v.

In this equation the reference clock is far from any gravitational field and is stationary relative to the TI field.

$$t_{test}\ /\ t_{ref} = 1\ /\ (\ 1 - v^2\ /\ c^2\ )^{1/2} \qquad \text{(B-2)}$$

where

t_{test} is the period of the test clock within the gravitational field of gravitational body (GB).

t_{ref} is the period of the reference clock that is far removed from any gravitational field.

v is the infall velocity of the TI field at the test clock. The reference clock is stationary relative to the TI field.

c is the velocity of light relative to the TI field.

B.3 Gravitational Time Dilation [5]

Equation (B-3) shows that the period of a clock (example of a process) within a gravitational field is greater (the clock ticks more slowly) than an identical clock far removed from any gravitational field. It is shown in Section B.6 that Eq (B-2) and Eq (B-3) yield identical results for the ratio of clock periods when the expression for the escape velocity is substituted for v in Eq (B-2).

$$t_{test} / t_{ref} = 1 / [1 - 2 G M_{act} / (r c^2)]^{1/2} \qquad \text{(B-3)}$$

where

t_{test} is the period of the test clock within the gravitational field of a gravitational body (GB). In this equation the test clock is stationary relative to the GB.

t_{ref} is the period of the reference clock far removed from any gravitational field. The reference clock is stationary relative to the TI field.

G is the universal gravitational constant.

M_{act} is the active gravitational mass of the GB.

r is the distance of the test clock from the gravitational center of the GB.

B.4 Gravitational Redshift [4]

I have affirmed in Section 3.0, Table 2 that gravitational redshift is caused by time dilation of the emitter (at, say, a star) and that this same value of redshift is measured at the receiver. ***The measured gravitational redshift is the same as the redshift emitted by the source.***

The usual form in which gravitational redshift is expressed asserts that the emitted wavelength of photons increases as the photons move from a strong gravitational field to a weaker one. In contradiction, I must express gravitational redshift to show its origin in the time dilation of the emitter.

Equation (B-4) shows that the wavelength of photons emitted in a gravitational field is greater than those emitted by an identical source far removed from any gravitational field. Understand that the observed wavelength is the same value as the emitted wavelength, provided the observer is located far from any gravitational field, else we'd have to consider the effect of time dilation of the receiver as well.

$$\lambda_{emit} / \lambda_{000} = 1 / [1 - 2 G M_{act} / (r c^2)]^{1/2} \qquad \text{(B-4)}$$

where

λ_{emit} is the wavelength of a photon emitted by a source located a distance r from the gravitational center of the gravitational body (GB). This is the source of photons within the gravitational field of the GB that are to be measured in a weaker gravitational field.

λ_{000} is the wavelength of a photon emitted by an identical source located far from any gravitational field. This is the reference wavelength by which photons from the source within the gravitational field of the GB are to be compared.

G is the universal gravitational constant.

M_{act} is the active gravitational mass of the GB.

r is the distance of the source of radiation from the gravitational center of the GB.

B.5 Gravitational Blueshift

Equation (B-5) shows the wavelength of a photon that was emitted far from a gravitational field and that is measured by an observer within a gravitational field is less than the emitted wavelength.

$$\lambda_{obs} / \lambda_{emit} = [1 - 2 G M_{act} / (r c^2)]^{1/2} \quad \text{(B-5)}$$

where

λ_{obs} is the wavelength of a photon measured by an observer located a distance r from the gravitational center of the gravitational body (GB).

λ_{emit} is the wavelength of a photon emitted by the source located far from any gravitational field.

G is the universal gravitational constant.

M_{act} is the active gravitational mass of the GB.

r is the distance of the observer from the gravitational center of the GB.

As in the case of gravitational redshift we can attribute the apparent change in wavelength to the time dilation of the receiver located within the gravitational field. The process of the receiver is slower than its counterpart outside a gravitational field and hence it measures the frequency of photons to be higher, and their wavelength shorter, than if the receiver were not slowed by time dilation. The measured increase in wavelength of photons is illusory and an artifact of the measurement itself.

B.6 Escape Velocity [3]

The escape velocity from a gravitational body is given by Eq (B-6).

$$v = (2 G M_{act} / r)^{1/2} \quad \text{(B-6)}$$

where

v is the escape velocity from the GB at a distance r from the gravitational center of the GB.

G is the universal gravitational constant.

M_{act} is the active gravitational mass of the GB.

r is the distance of the point of measurement from the gravitational center of the GB.

Substitute the expression for velocity v from Eq (B-6) into Eq (B-2) and you get Eq (B-3) which suggests that if a process were moving at a velocity (relative to the TI field) equal in magnitude to the escape velocity from a gravitational body (GB) at a distance r from the GB the process would experience the same magnitude time dilation as gravity would produce at that radius.

This equality supports the assertion that gravitational time dilation is caused directly by the velocity of the process relative to the TI field, not directly by gravity.