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The Pound-Rebka Experiment:

An Analysis of the Gravitational Effect on the Frequency of Light

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***Abstract*:**

The main objective, in the present investigation, is to calculate the theoretical predictions concerning the effects of gravitational fields, on rising and falling electromagnetic radiation, in accordance with the assumption of constant speed of light, on the basis of which the speed of light is independent of the speed of the light source, as well as in accordance with the assumption of ballistic speed of light, on the basis of which the speed of light is dependent upon the speed of the light source, respectively; and to finally compare the numerical results of the computed predictions to the reported result of the Pound-Rebka Experiment.

Keywords:

Gravitational redshift; weight of light; acceleration; constant speed of light; Einstein's elevator; ballistic speed of light; Pound-Rebka Experiment; gamma rays; equivalence principle; particle

beams; uniform gravitational fields.

Introduction:

R. V. Pound & G. A. Rebka, in their ***1960*** experimental report, have stated that the gravitational redshift, as calculated by Albert Einstein on the basis of the assumption of constant speed of light, according to which the speed of light is independent of the speed of the light source, and Einstein's principle of equivalence between a mechanically accelerated elevator and an elevator at rest in a gravitational field, has been, experimentally, tested and verified [***Ref. #1a & Ref. #1b***].

However, in Einstein's calculations of the effect, in question, the light source and the Doppler-shift detector have been assumed to be at rest with respect to each other and relative to the gravitational field under investigation.

While, for some technical reasons, R. V. Pound & G. A. Rebka, by contrast, have chosen, in their experiment, to move the gamma-ray source with varying amounts of velocity, ranging from slightly greater than $(\boldsymbol{0})\ \boldsymbol{ms^{-1}}$ to about $(\boldsymbol{7 \times 10^{-6}})\ \boldsymbol{ms^{-1}}$; relative to the gamma-ray absorber and relative to Earth's gravitational field, at the same time, until the optimal velocity, $\boldsymbol{v}$, at which the calculated effect and the Doppler effect, due to the motion of the light source, cancel each other out, is found:

$$v \approx \frac{gh}{c} = 7.36 \times 10^{-7} \ \ \mathrm{ms^{-1}}$$

where $\boldsymbol{g}$ is the gravitational acceleration; and $\boldsymbol{h}$ is the vertical distance between the gamma-ray source and the gamma-ray absorber.

Notwithstanding its incredibly tiny magnitude, the relative velocity assigned above, by R. V. Pound & G. A. Rebka, to the gamma-ray source, introduces, at once, considerable computational and theoretical difficulties, which, upon close examination, have the real potential of rendering their experimental evidence, for Einstein's gravitational redshift, completely, inconclusive:

1. The optimal amount of velocity, given, by R. V. Pound & G. A. Rebka, to the gamma-ray source above, is equal to the amount of uniform motion lost or gained by gamma rays rising to or falling from a vertical distance of ***22.5*** meters above Earth's surface, under the effect of Earth's gravitational field. But gamma rays are electromagnetic radiation. And, of course, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source, electromagnetic radiation, by definition, is not allowed to accelerate, in any conceivable way, under the sway of gravitational fields.

2. The problem of accelerating electromagnetic radiation, however, lies at the heart of Einstein's principle of equivalence, itself. Einstein's principle of equivalence is, typically, defined in terms of equivalence between mechanical acceleration and gravitational acceleration. But that presents a major theoretical problem. That is because the equivalence between mechanical acceleration and gravitational acceleration, in the final analysis, is nothing more than the equivalence between an elevator, laboratory, or any other frame of reference, accelerating relative to electromagnetic radiation, on one hand; and electromagnetic radiation accelerating relative to a stationary elevator, laboratory, or any other frame of reference, on the other hand. And so, Einstein's principle of equivalence contains, within itself, the basic contradiction between accelerating electromagnetic radiation and the assumption of constant speed of light, on the basis of which the speed of light is independent of the speed of the light source.

3. The motion of the gamma-ray source, relative to the gravitational field of the earth, changes the the Doppler effect, during the rest wave period, ***T***, from its numerical value, in free space, to its numerical value, as measured by the gamma-ray absorber, by an amount equal to $\boldsymbol{\Delta z}$:

$$\Delta z = +\left(\frac{gT}{c}\right)$$

in the case falling gamma rays; &:

$$\Delta z = -\left(\frac{gT}{c}\right)$$

in the case of rising gamma rays.

However, the above amount is too minute to be detected, in the experiment under discussion.

4. The most important change, brought about by the motion of the gamma-ray source inside Earth's gravitational field, is, by far, the change in the numerical value of that motion, itself, during the rest wave period, ***T***, by an amount equal to $\boldsymbol{\Delta v}$:

$$\Delta v = +gT$$

in the case falling gamma rays; &:

$$\Delta v = -gT$$

in the case of rising gamma rays;
where ***T*** is the rest wave period of emitted gamma rays, in the two cases, respectively.

And that is because the presence of the velocity difference $\pm \boldsymbol{gT}$; i.e.,

$$gT \neq 0$$

is the basic condition and the necessary requirement for calculating the gravitational Doppler shift, on the basis of the ballistic assumption, according to which the speed of light is dependent upon the speed of the light source. In particular, it's quite simple and very easy, as well, in the case of a moving gamma-ray source, to account for and to interpret, in a straight forward manner, the reported experimental result of the Pound-Rebka Experiment, in accordance with the assumption of ballistic speed of light, as defined within the framework of the elastic-impact emission theory, and similar physical theories of light.

Although, in the published ligature, there is no mention of whether it's possible, in practice, or not, for the Pound-Rebka Experiment, to be carried out, with a stationary gamma-ray source, the case, in which the gamma-ray source is at rest relative to the gamma-ray absorber and relative to the gravitational field, is the only case that can provide a clear and decisive experimental evidence for or against the theoretical prediction labeled, conventionally, as '*Einstein's gravitational redshift*'.

And the main reason, of course, is that, in the case, in which the gamma-ray source, the gamma-ray absorber, and the gravitational field, are all at rest relative to each other, the computed results, on the basis of the ballistic assumption, according to which the speed of light is dependent upon the speed of the light source, predict that the force of gravity changes neither the rest wave periods nor the rest frequencies of the emitted gamma rays; that is to say, according to those calculations, there is, absolutely, in this particular case, no gravitational Doppler shift, at all.

But how, exactly, does the ballistic assumption, on the basis of which the speed of light depends upon the speed of the light source, make the Pound-Rebka experimental evidence, for the existence of Einstein's gravitational redshift, entirely, inconclusive?

On the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent on the speed of the light source, propagation of electromagnetic radiation, in a gravitational field, changes, in all cases, the numerical values of travel time, intensity, spatial frequency, and speed; but it does change the wave period and the temporal frequency of electromagnetic radiation.

Nonetheless, the motion of the electromagnetic-radiation source, in a gravitational field, has a significant effect, directly, proportional to distance, on both the wave period and the temporal frequency of emitted electromagnetic radiation from that source:

Let's assume that $\boldsymbol{v}$ denotes the velocity of the gamma-ray source; $\boldsymbol{g}$ denotes the gravitational acceleration on Earth's surface; & $\boldsymbol{h}$ denotes the height of the Pound-Rebka tower.

In the case of falling gamma rays, the gamma-ray source is receding from the emitted gamma rays; and hence, according to the assumption of ballistic speed of light, on the basis of which the speed of light depends upon the speed of the light source, the speed of gamma rays, at the start of the rest wave period, $\boldsymbol{T}$, is equal to $\boldsymbol{c'}$:

$$c' = c - v$$

where ***c*** is the muzzle speed of light;

& the speed of gamma rays, at the end of the rest wave period, ***T***, is equal to ***c″***:

$$c'' = c - v + gT$$

where ***g*** is the gravitational acceleration.

And accordingly, the speed difference is equal to ***Δc***:

$$\Delta c = c'' - c' = gT$$

where ***T*** is the rest wave period of emitted gamma rays.

The above speed difference, in calculations based on the ballistic assumption, produces, during the light propagation inside the gravitational field, and outside the gravitational field, as well, an amount of Doppler blue shift, which increases, linearly, with the increasing distance from the gamma-ray source, as well as with the increasing elapsed interval of time since emission.

At a distance, from the gamma-ray source, equal to ***cT***, for example, the speed difference, ***Δc***, reduces the wave period, ***T′***, shifted by the motion of the gamma-ray source, in accordance with the following equation:

$$T' = T\left(\frac{c}{c - v + gT}\right)$$

where ***v*** is the speed of the gamma-ray source.

And consequently, it increases the temporal frequency ***f′***, which is, initially, shifted due to the motion of the gamma-ray source, by a very small amount, according to this equation:

$$f' = \frac{1}{T'} = f\left(1 - \frac{v - gT}{c}\right)$$

where ***gT*** is the speed difference, due to the effect of Earth's gravitational field, on the moving gamma-ray source, during the time of emission.

While, at a distance, from the gamma-ray source, equal to the height of the Pound-Rebka tower, ***h***, the Doppler blue shift, due to the speed difference, ***Δc***, balances out the Doppler red shift, due to the motion of the light source, and restores the numerical value of the rest wave period, ***T***.

In general, if the numerical value of the speed difference, ***Δc***, is equal to ***+gT***, then it decreases the rest wavelength of emitted electromagnetic radiation, ***λ***, in accordance with the following formula:

$$\lambda' = \lambda - gT\left(t - T\right)$$

where ***t*** is the elapsed interval of time since emission.

And if the numerical value of the speed difference, ***Δc***, is equal to ***-gT***, then it increases the rest wavelength of emitted electromagnetic radiation, ***λ***, in accordance with this formula:

$$\lambda' = \lambda + gT\left(t - T\right)$$

where ***g*** is the gravitational acceleration; and ***T*** is the rest wave period of electromagnetic radiation.

However, even though the numerical values of the Doppler shift, due to the speed difference, ***Δc***, as computed on the basis of the assumption of ballistic speed of light, are equal to the numerical values of Einstein's gravitational redshift, as calculated in accordance with the assumption of constant speed of light and Einstein's principle of equivalence, the two effects are quite different, in many respects:

- The Doppler shift, due to the speed difference, ***Δc***, as calculated on the basis of the assumption of ballistic speed of light, is caused by the effect of the gravitational field on the light source, during the time of emission.

- Einstein's gravitational redshift, as calculated on the basis of the assumption of constant speed of light and Einstein's principle of equivalence, is caused by the effect of the gravitational field on light, itself, during the time of propagation.

- The Doppler shift, due to the speed difference, ***Δc***, as computed in accordance with the assumption of ballistic speed of light, continues to change the wave periods and the frequencies of electromagnetic radiation, in direct proportion to the length of the light path, both inside and outside the gravitational field, indefinitely.

- Einstein's gravitational redshift, as calculated on the basis of the assumption of constant speed of light and Einstein's principle of equivalence, changes the wave periods and the frequencies of electromagnetic radiation only, during the propagation of light inside the gravitational field.

- The sign of the Doppler shift, due to the speed difference, Δc, as calculated according to the assumption of ballistic speed of light, depends on the direction of the motion of the light source with respect to the gravitational field.

- The sign of Einstein's redshift, as computed in accordance with the assumption of constant speed of light and Einstein's principle of equivalence, depends upon the direction of the propagation of light with respect to the gravitational field.

- The magnitude of the Doppler shift, due to the speed difference, Δc, as computed on the basis of the assumption of ballistic speed of light, depends upon the magnitude of the gravitational acceleration acting on the moving light source inside the gravitational field, during the time of emission.

- The magnitude of Einstein's redshift, as calculated according to the assumption of constant speed of light and Einstein's principle of equivalence, depends on the magnitude of the gravitational acceleration acting on light, itself, during the time of propagation inside the gravitational field.

And it follows, therefore, that the Pound-Rebka Experiment, because of the motion of the gamma-ray source relative to the gamma-ray absorber and relative to Earth's gravitational field, can neither determine nor verify whether the expected Doppler effect of this optimal speed, $\boldsymbol{v}$:

$$v \approx \frac{gh}{c} = 7.36 \times 10^{-7} \ \ \mathrm{ms^{-1}}$$

disappears and gets canceled out, because of the presence of Einstein's gravitational redshift, as calculated in accordance with the assumption of constant speed of light and Einstein's principle of equivalence; or because of the presence of the Doppler shift, due to the speed difference, Δc, as computed on the basis of the assumption of ballistic speed of light, in the case, in which the light source is moving inside the gravitational field at the time of emission.

1. The Pound-Rebka Experiment:

In this experiment, a beam, from a ***14.4***-keV-Fe^{57}-gamma-ray source, is sent, through a helium-filled plastic bag, towards a gamma-ray absorber located about ***22.5*** meters higher, in the case of rising gamma rays, and lower, in the case of falling gamma rays, than the gamma-ray source.

In addition, a constant velocity is introduced by coupling a hydraulic cylinder of large bore carrying the transducer and the gamma-ray source to a master cylinder of small bore connected to a rack and pinion driven by a clock [***Ref. #1a-b***].

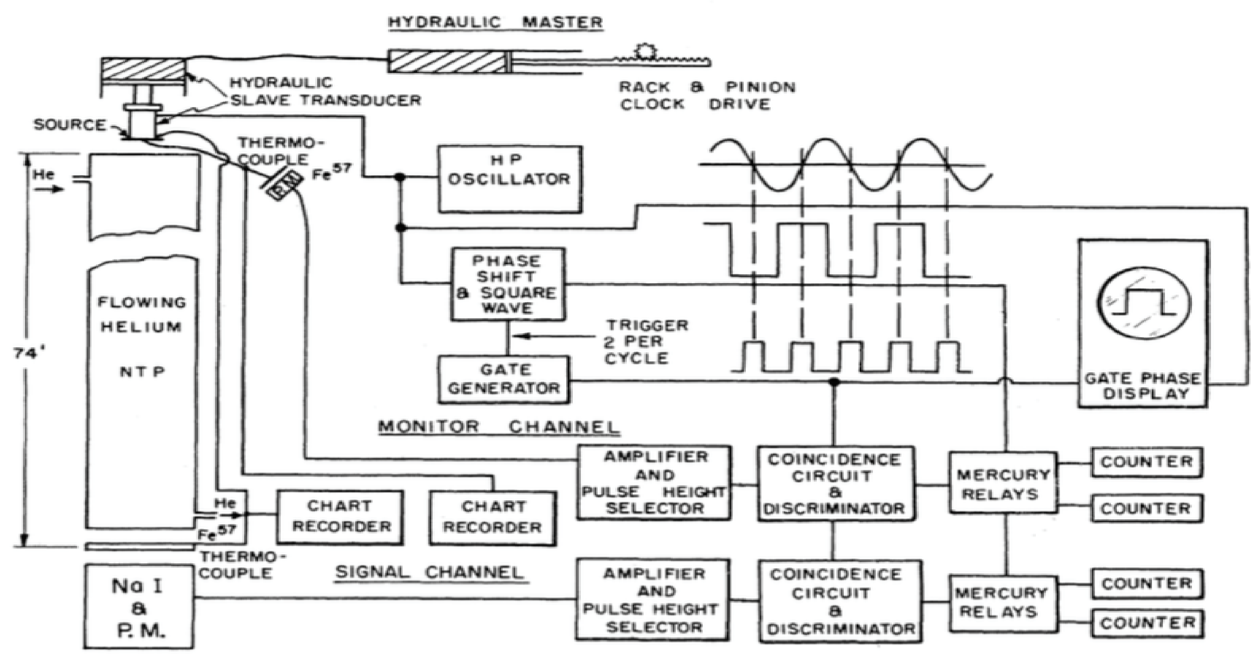

FIG. 1. A block diagram of the over-all experimental arrangement. The source and absorber-detector units were frequently interchanged. Sometimes a ferroelectric and sometimes a moving-coil magnetic transducer was used with frequencies ranging from 10 to 50 cps.

Fig. #1: *The Pound-Rebka Experiment*

The main purpose of the Pound-Rebka Experiment is to measure the counting rate difference and relative frequency shifts between the emission and absorption lines directly by adding a Doppler shift several times the size of the predicted gravitational effect on the emission line of the gamma-ray beam, in the two cases of rising and falling gamma rays under the sway of the gravitational field of the earth.

Thus, through the linear interpolation between the effects of the slow calibrating velocities, it has been possible to determine the gamma-ray source's velocity that would make the difference between the shifts of the main absorber and the monitor absorber, found in the case of the upward beam, identical to the difference, measured in the case of the downward beam.

In the *1964* Jefferson-Physical-Laboratory Repetition of the *1960* Pound-Rebka Experiment, in which the gamma-ray source is moved alternately upward and downward by a hydraulic piston at a speed of about 7×10^{-4} cm/sec, for periods each containing ***22001*** modulation cycles, R. V. Pound & J. L Snider have reported an overall result of ***0.9970*** times the computed value, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source, and Einstein's principle of equivalence [***Ref. #2***].

The following aspects of the Pound-Rebka Experiment, should be pointed out and made clear:

- In the case of falling gamma rays, the gamma-ray source is located at a height of ***22.5*** meters above the gamma-ray absorber, and receding, directly, from the emitted gamma rays. The experimental objective, here, is to measure the value of the optimal speed, at which the Doppler red shift, generated by the receding gamma-ray source, and Einstein's gravitational blue shift, cancel each other out.

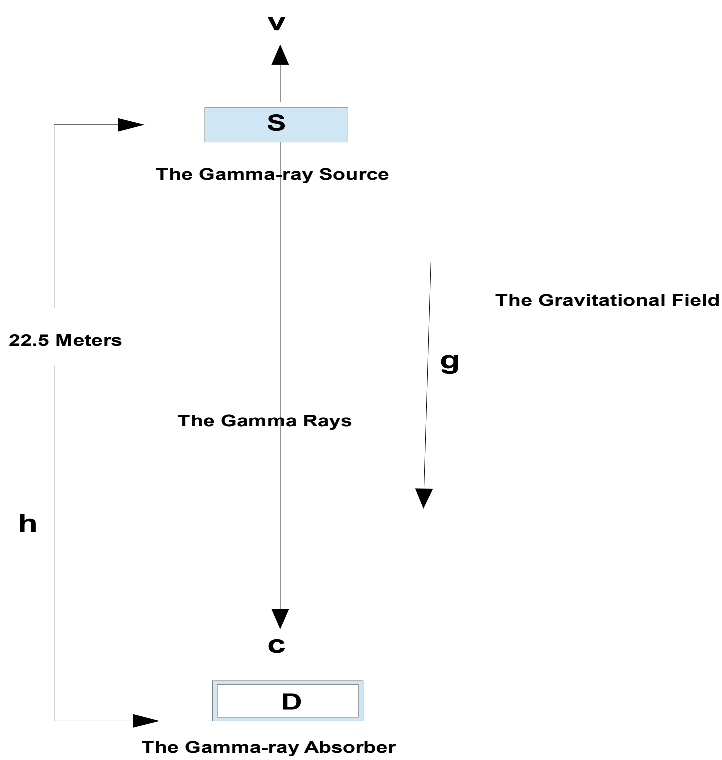

Fig. #2: *Falling Gamma Rays*

- In the case of rising gamma rays, the gamma-ray absorber is located at a height of ***22.5*** meters above the gamma-ray source. At the same time, the gamma-ray source is moving upward, directly, behind the emitted gamma rays. And the experimental objective, here as well, is to measure the value of the optimal speed, at which the Doppler blue shift, generated by the approaching gamma-ray source, and Einstein's gravitational redshift, balance each other out.

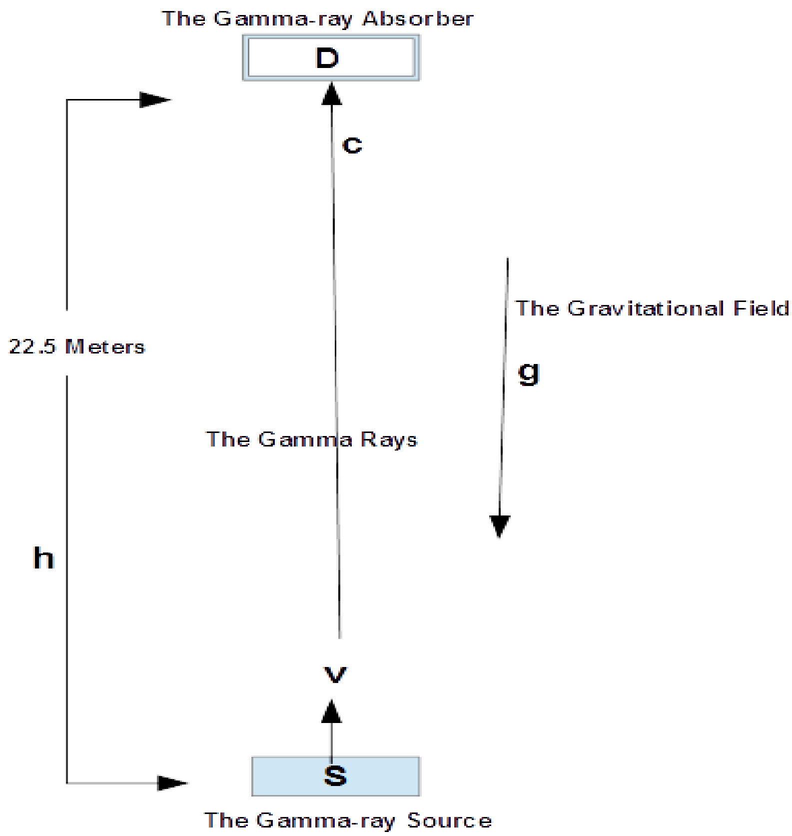

Fig. #3: *Rising Gamma Rays*

- In the case of falling gamma rays, the region between the gamma-ray source and the gamma-ray absorber, in the Pound-Rebka experimental setup, is dominated by the Doppler red shift of the moving gamma-ray source. While, in Einstein's elevator, by contrast, the region between the light source and the Doppler-shift detector, is dominated by the gravitational blue shift of the falling light.

- In the case of rising gamma rays, the region between the gamma-ray source and the gamma-ray absorber, in the Pound-Rebka experimental setup, is dominated by the Doppler blue shift of the moving gamma-ray source. While, in Einstein's elevator, by comparison, the region between the light source and the Doppler-shift detector, is dominated by the gravitational redshift of the rising light.

- The above Pound-Rebka experimental setup — as ingenious as is — does not correspond, exactly, with the two-fixed-point scenario, for which Albert Einstein's calculated his gravitational redshift; and in which he, explicitly, assumed that the light source and the detector are at rest relative to each other and relative to the gravitational field. And, subsequently, the Pound-Rebka Experiment does not constitute a direct test and straightforward experimental verification of the predicted value of Einstein's gravitational redshift, as calculated on the basis of Einstein's principle of equivalence, and the assumption of constant speed of light, according to which the speed of light is independent of the speed of the light source.

- And furthermore, the motion of the gamma-ray source, in the above experimental setup, makes the numerical value, for the gravitational redshift, as calculated on the assumption of constant speed of light along with Einstein's principle of equivalence, and the numerical value, for the Doppler shift, due to the speed difference, Δc, as calculated on the assumption of ballistic speed of light, identical and exactly the same. And as a result, it is not possible for the Pound-Rebka Experiment to differentiate, decisively, between the computed predictions on the basis of these two diametrically opposed assumptions regarding the speed of electromagnetic radiation.

In the following sections, the relevant theoretical predictions will be computed, on the basis of the assumption of constant speed of light and Einstein's principle of equivalence, and on the basis of the assumption of ballistic speed of light and the speed difference, Δc, respectively. And the numerical results of those calculations, in both cases, will be compared to the published result of the Pound-Rebka Experiment.

2. Computed Predictions on the Assumption of Constant Speed of Light:

It's, undoubtedly, next to impossible, from any theoretical standpoint, to derive, directly, the mathematical formulas of Doppler effect on electromagnetic radiation, due to the force of gravity, based upon the assumption of constant speed of light, as defined within the theoretical framework of the classical wave theory of light and other similar physical theories.

That is because, on the assumption of constant speed of light, according to which the speed of light is independent of the speed the light source, gravitational fields are not permitted, by their very definition, to accelerate any part of the electromagnetic spectrum, under any circumstances.

In order to overcome the above theoretical difficulty, however, Albert Einstein has proposed the employment of the following three-step procedure [***Ref. #3*** **&** ***Ref. #4***]:

I. Imagine that there are two elevators, one elevator is at rest, under the effect of the gravitational field of Earth; while the other elevator is in outer space and accelerating, mechanically, with an acceleration equal to the gravitational acceleration, here, on the earth's surface.

II. Derive the relevant equations, for the Doppler effect, due to mechanical acceleration, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source.

III. And finally, assume that mechanical acceleration and gravitational acceleration are equivalent to each other, and use the derived Doppler formulas, for electromagnetic radiation traveling inside the mechanically accelerating elevator, to calculate the gravitational redshift, due to the effect of the force of gravity on electromagnetic radiation, traveling inside the stationary elevator on the surface of the earth.

In the following discussion, the related equations, for calculating the Doppler effect, due to mechanical acceleration, will be derived, on the basis of the assumption of constant speed of light, as defined within the framework of the classical wave theory and other similar theories of light.

Let h denote the height of Einstein's elevator in outer space.

And let a stand for the acceleration of the same elevator due to a mechanical force.

There are two different methods for deriving the mathematical formulas, needed, within the current context, for calculating the predicted shifts in wave periods and frequencies of electromagnetic radiation, in the case of mechanical acceleration, and in the case of gravitational acceleration, respectively:

- The first method, for deriving the related formulas, is to compute the total travel time of light, t; and to obtain the uniform velocity of the accelerating frame of reference, v, in question, through the use of this equation:

  $$v = at$$

  where a stands for mechanical acceleration;

  and then by using the uniform velocity, v, along with the rest wave period, T, the rest wavelength, cT, and the speed of light, c, it's possible to calculate the shifted wave period, T', the shifted frequency, ***f′***, and the Doppler shift, ***z***, for light traveling with respect to the accelerating frame of reference, under investigation.

- The second method, for deriving the aforementioned formulas, is to compute the total travel time of light, t_1, emitted at the start of the rest wave period, ***T***; and the total travel time of light, t_2, emitted at the end of the same rest wave period, ***T***, and then to use both together, in order to obtain the shifted wave period, ***T′***, in accordance with the following equation:

$$T' = T + (t_2 - t_1)$$

and to finally use the computed shifted wave period, ***T′***, to calculate the shifted frequency, ***f′***, and the Doppler shift, ***z***, for the received light with respect to the accelerating frame of reference, under discussion.

Although it's conceivable that the uniform motion of Einstein's elevator, due to its mechanical acceleration, can, in principle, produce second-order effects, in accordance with the assumption of constant speed of light, as employed within the theoretical framework of the classical wave theory of light, only the part of uniform motion, gained by the accelerated elevator, during the travel time of light from the floor to the ceiling, or vice versa, is, in practice, detectable by observers inside that elevator.

And these are the two major detectable cases:

A. The case of light traveling from the floor to the ceiling of Einstein's elevator:

If a stationary light source, located on the floor, emits its light towards a stationary detector, placed on the ceiling of Einstein's elevator, then, on the basis of the assumption of constant speed of light, according to which the speed of light is independent of the speed of the light source, the travel time of emitted light, ***t***, from the floor to the ceiling of Einstein's elevator, can be computed by using the following equation:

$$t = \frac{h + \frac{1}{2}at^2}{c} = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

where ***t*** is the travel time of light from the floor to the ceiling of Einstein's elevator; ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

And accordingly, during the travel time of light from the floor to the ceiling, Einstein's elevator gains a total amount of uniform motion equals to ***v***:

$$v = at = c - \sqrt{c^2 - 2ah}$$

where ***c*** is the speed of light.

Because the light source, during the rest wave period, ***T***, is accelerating in the same direction as that of emitted light, the wavelength of received light is decreased by an amount equal to ***0.5aT²***.

And, therefore, the shifted wave period of light, ***T′***, as measured by a detector placed on the ceiling of Einstein's elevator, can be calculated by the means of this equation:

$$T' = \frac{cT - \frac{1}{2}aT^2 + vT' + \frac{1}{2}aT'^2}{c} = \frac{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2acT + a^2T^2}}{a}$$

where ***a*** is the mechanical acceleration; ***h*** is the height of the elevator; and ***T*** is the rest wave period of emitted light.

We can, also, obtain the same shifted wave period of received light, ***T′***, through the application of the second method:

The total travel time of light emitted at the start of the rest wave period, ***T***, is equal to t_1:

$$t_1 = \frac{h + \frac{1}{2}at_1^2}{c} = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

where ***c*** is the speed of light; ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

And the total travel time of light emitted at the end of the rest wave period, ***T***, is equal to t_2:

$$t_2 = \frac{h + (aT)t_2 + \frac{1}{2}at_2^2}{c} = \frac{(c - aT) - \sqrt{(c - aT)^2 - 2ah}}{a}$$

where ***aT*** is the uniform velocity gained by Einstein's elevator, during the rest wave period, ***T***.

And so, the shifted wave period of received light, ***T′***, can be, now, obtained by using this equation:

$$T' = T + (t_2 - t_1) = \frac{\sqrt{c^2 - 2ah} - \sqrt{(c - aT)^2 - 2ah}}{a}$$

which is the same shifted wave period of received light, ***T'***, as obtained, earlier, by the application of the first method.

And correspondingly, the shifted frequency of received light, ***f'***, is given by this equation:

$$f' = \frac{1}{T'} = \frac{a}{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2acT + a^2T^2}}$$

And therefore, the Doppler red shift of light traveling from the floor to the ceiling of Einstein's elevator, as predicted, on the basis of the assumption of constant speed of light, is equal to ***z***:

$$z = \frac{f - f'}{f} = 1 - \frac{a/f}{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2acT + a^2T^2}}$$

where ***f*** is the rest frequency of emitted light; and ***f'*** is the shifted frequency of received light.

And so, the maximum value of the uniform velocity of Einstein's elevator, as obtained from the total Doppler shift of light traveling from the floor to the ceiling, equal to ***v'***:

$$v' = zc = c\left(1 - \frac{a/f}{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2acT + a^2T^2}}\right) = c - \frac{a/f}{\sqrt{1 - \frac{2ah}{c^2}} - \sqrt{1 - \frac{2ah}{c^2} - \frac{2aT}{c} + \frac{a^2T^2}{c^2}}}$$

where ***a*** is the mechanical acceleration of Einstein's elevator; and ***c*** is the speed of light.

And it follows, therefore, that, by applying Einstein's principle of equivalence between mechanical acceleration and gravitational acceleration, to the stationary elevator, on Earth's surface, we can obtain the following formula, for calculating the gravitational redshift of light traveling from the floor to the ceiling of the stationary elevator, under the effect of the force of gravity:

$$z = \frac{f - f'}{f} = 1 - \frac{g/f}{\sqrt{c^2 - 2gh} - \sqrt{(c - gT)^2 - 2gh}}$$

where ***z*** is Einstein's gravitational redshift, due to the gravitational field of the earth; ***g*** is the gravitational acceleration, on Earth's surface; and ***T*** is the rest wave period of emitted light.

Now, let's calculate the gravitational redshift, due to Earth's gravitational acceleration, on light traveling inside Einstein's stationary elevator, and the equivalent uniform velocity, by inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a & Ref. #2***], into the above equation:

$$c = 299792458 \ \text{ms}^{-1}$$
$$g = 9.80665 \ \text{ms}^{-2}$$
$$h = 22.5 \ \text{m}$$
$$f = 3.46 \times 10^{18} \ \text{Hz}$$

It should be noted that, in order to avoid the rounding errors of floating points and the infamous '*catastrophic cancellations*', in quadratic formulas [***Ref. #5***], it's necessary to use a high precision calculator, in the current calculations.

The following numerical results are obtained, through the use of the desktop calculator, '*SpeedCrunch* ***0.12'*** (Portable Edition), with its precision set to ***50*** digits:

$$z = 2.455058176 \times 10^{-15}$$
$$v' = 7.36007925 \times 10^{-7} \ \text{ms}^{-1}$$

where ***z*** is Einstein's gravitational redshift; and ***v'*** is the equivalent uniform velocity, with respect to the reference frame of the stationary elevator.

By comparison, inserting the same numerical data, above, into this conventional equation:

$$f' = f\left(1 - \frac{gh}{c^2}\right)$$

for computing Einstein's gravitational redshift, due to the effect of the force of gravity, on rising electromagnetic radiation [***Ref. #6***], gives the following results:

$$z = 2.455058176 \times 10^{-15}$$
$$v' = 7.36007925 \times 10^{-7} \text{ ms}^{-1}$$

where z is Einstein's gravitational redshift; and v' is the equivalent uniform velocity, as computed in the frame of reference, in which Einstein's elevator is at rest.

It should be pointed out, in this regard, that the above conventional formula is obtained by neglecting the two terms, $0.5gT^2$ & $0.5gT'^2$, which can produce, in the case of the Pound-Rebka Experiment, a velocity difference equal to about 10^{-33} ms^{-1}, and then by, simply, assuming that the travel time of light, from the floor to the ceiling of Einstein's elevator, is equal to t:

$$t = \frac{h}{c}$$

where c is the speed of light; and h is the height of Einstein's elevator.

B. The case of light traveling from the ceiling to the floor of Einstein's elevator:

If a stationary light source, located on the ceiling, emits its light towards a stationary detector, located on the floor of Einstein's elevator, then, on the basis of the assumption, in accordance with which the speed of light is independent of the speed of the light source, the travel time of emitted light, from the ceiling to the floor, t, can be computed by using the following equation:

$$t = \frac{h - \frac{1}{2}at^2}{c} = \frac{\sqrt{c^2 + 2ah} - c}{a}$$

where t is the travel time of light from the ceiling to the floor of Einstein's elevator; h is the height of the same elevator; and a is the mechanical acceleration.

And hence, during the travel time of emitted light from the ceiling to the floor, Einstein's elevator will have to gain a total amount of uniform motion equals to v:

$$v = at = \sqrt{c^2 + 2ah} - c$$

where c is the speed of light.

Since the light source, during the rest wave period, T, is accelerating in the opposite direction to that of the emitted light, the wavelength of received light is increased by an amount equal to $0.5aT^2$.

And, therefore, the shifted wave period of received light, T', as measured by a detector at rest on the floor of Einstein's elevator, can be calculated by using this equation:

$$T' = \frac{cT + \frac{1}{2}aT^2 - vT' - \frac{1}{2}aT'^2}{c} = \frac{\sqrt{c^2 + 2ah + 2acT + a^2T^2} - \sqrt{c^2 + 2ah}}{a}$$

where a is the mechanical acceleration; h is the height of the elevator; and T is the rest wave period of emitted light,

It can be shown that the same shifted wave period, T', above, is, also, obtainable through the use of the second method, as well.

And accordingly, the shifted frequency of received light, f', is given by this equation:

$$f' = \frac{1}{T'} = \frac{a}{\sqrt{c^2 + 2ah + 2acT + a^2T^2} - \sqrt{c^2 + 2ah}}$$

where T' is the shifted wave period of received light.

And it follows, therefore, that the Doppler blue shift of light traveling from the ceiling to the floor of Einstein's elevator, as predicted, on the basis of the assumption of constant speed of light, is equal to z:

$$z = \frac{f' - f}{f} = \frac{a/f}{\sqrt{c^2 + 2ah + 2acT + a^2T^2} - \sqrt{c^2 + 2ah}} - 1$$

where f is the rest frequency of emitted light; and f' is the shifted frequency of received light.

And it's clear, therefore, that the maximum value of the uniform velocity of Einstein's elevator, as obtained from the total Doppler blue shift of light traveling from the ceiling to the floor, is equal to v':

$$v' = zc = \frac{a/f}{\sqrt{1+\frac{2ah}{c^2}+\frac{2aT}{c}+\frac{a^2T^2}{c^2}}-\sqrt{1+\frac{2ah}{c^2}}} - c$$

where ***a*** is the mechanical acceleration of Einstein's elevator; and ***c*** is the speed of light.

And consequently, by applying Einstein's principle of equivalence between mechanical acceleration and gravitational acceleration, to the stationary elevator, located on Earth's surface, we can obtain the following formula, for calculating Einstein's gravitational blue shift of light traveling from the ceiling to the floor, under the sway of the force of gravity:

$$z = \frac{f'-f}{f} = \frac{g/f}{\sqrt{(c+gT)^2+2gh}-\sqrt{c^2+2gh}} - 1$$

where ***z*** is Einstein's gravitational blue shift, caused by the effect of the force of gravity on emitted light; ***g*** is the gravitational acceleration; and ***T*** is the rest wave period of emitted light.

And so, finally, it's possible to calculate the numerical value of the gravitational blue shift, due to Earth's gravitational acceleration, on light traveling from the ceiling to the floor of Einstein's stationary elevator, and the equivalent uniform velocity, by inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a & Ref. #2***], into the above equation:

$$c = 299792458 \text{ ms}^{-1}$$
$$g = 9.80665 \text{ ms}^{-2}$$
$$h = 22.5 \text{ m}$$
$$f = 3.46\times10^{18} \text{ Hz}$$

But it should be noted, first, that, in order to avoid the rounding errors of floating points and the so-called '*catastrophic cancellations*', in quadratic formulas [***Ref. #5***], we have to use a high precision calculator, for obtaining the related numerical values in the current calculations.

And here, once again, the following numerical results have been obtained, through the use of the desktop calculator, *SpeedCrunch* ***0.12*** (Portable Edition), with its precision set to ***50*** digits:

$$z = 2.455058176 \times 10^{-15}$$
$$v' = 7.36007925 \times 10^{-7} \text{ ms}^{-1}$$

where z is Einstein's gravitational blue shift; and v' is the equivalent uniform velocity, as calculated in the reference frame of of the stationary elevator.

By comparison, inserting the same numerical data, above, into this conventional equation:

$$f' = f\left(1 + \frac{gh}{c^2}\right)$$

for computing the predicted gravitational blue shift, due to Earth's gravitational field, [***Ref. #6***], gives the following results:

$$z = 2.455058176 \times 10^{-15}$$
$$v' = 7.36007925 \times 10^{-7} \text{ ms}^{-1}$$

where z is the predicted gravitational blue shift; and v' is the equivalent uniform velocity, as computed in the frame of reference, in which Einstein's elevator is at rest.

It should be clear, within this context, that the aforementioned conventional formula is obtained by neglecting the two mathematical terms, $0.5gT^2$ & $0.5gT'^2$, which can produce, in the case of the Pound-Rebka Experiment, a velocity difference equal to about 10^{-33} ms^{-1}, and then, by quite simply, assuming that the travel time of light, from the ceiling to the floor of Einstein's elevator, t, can be obtained through the use of this formula:

$$t = \frac{h}{c}$$

where c is the speed of light; and h is the height of Einstein's elevator.

3. Computed Predictions on the Assumption of Ballistic Speed of Light:

Since the assumption of ballistic speed of light does not, theoretically, restrict the acceleration of the electromagnetic spectrum, under the effect of gravitational fields, in any way; there should be no theoretical difficulty in deriving, directly, the mathematical formulas of the Doppler effect on electromagnetic radiation, due to the force of gravity, based upon the assumption of ballistic speed of light, as defined within the theoretical framework of the elastic-impact emission theory, and other ballistic theories of light, in general.

Nonetheless, the quantitative treatment of mechanical acceleration, along with the quantitative treatment of gravitational acceleration, within the present context, is required for comparing the theoretical predictions, based on the two principal assumptions, under investigation, and for illustrating the striking equivalence between the case, in which a frame of reference is accelerating relative to electromagnetic radiation, and between the case, in which electromagnetic radiation is accelerating relative to a frame of reference, in calculations based on the assumption of ballistic speed of light.

A. Mechanical Acceleration:

The uniform motion, gained by Einstein's elevator, due to its mechanical acceleration, prior to the emission of light, does not produce any measurable amount of Doppler effect, on electromagnetic radiation traveling from the floor to the ceiling, or from the ceiling to the floor of that elevator, in accordance with the ballistic assumption, on the basis of which the speed of light is dependent upon the speed of the light source.

Let ***h*** stand for the height of an accelerating elevator in outer space.

And let ***a*** denote the acceleration of the same elevator by the application of a mechanical force.

I. In the case of light traveling from the floor to the ceiling of Einstein's elevator:

If a light source, placed at rest on the floor, emits its light towards a detector, at rest on the ceiling of Einstein's elevator, then, on the basis of the assumption of ballistic speed of light, the total travel time of emitted light, from the floor to the ceiling of Einstein's elevator, ***t***, can be computed through the use of the following equation:

$$t = \frac{h + \frac{1}{2}at^2}{c} = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

where ***t*** is the total travel time of light from the floor to the ceiling of Einstein's elevator; ***h*** is the height of Einstein's elevator; and ***a*** is the mechanical acceleration.

And thus, during the travel time of emitted light from the floor to the ceiling, Einstein's elevator, itself, must gain a total amount of uniform motion, relative to received light, equals to ***v***:

$$v = at = c - \sqrt{c^2 - 2ah}$$

where ***c*** is the muzzle speed of light.

And because the light source, during the rest wave period, ***T***, is accelerating in the same direction as that of emitted light, the wavelength of received light is decreased by an amount equal to $\boldsymbol{0.5aT^2}$; while, at the same time, the velocity of light is increased by an amount equal to ***aT***.

And, consequently, the shifted wave period of received light, ***T'***, as measured by a detector at rest on the ceiling of Einstein's elevator, can be calculated through the use of the following equation:

$$T' = \frac{cT - \frac{1}{2}aT^2 - aT\left(t - T\right) + vT' + \frac{1}{2}aT'^2}{c + aT} = T$$

where ***a*** is the mechanical acceleration; ***h*** is the height of the elevator; ***T*** is the rest wave period of emitted light; and ***aT(t - T)*** is calculated in accordance with this equation:

$$aT\left(t - T\right) = T\left(c - \sqrt{c^2 - 2ah}\right) - aT^2$$

where ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

It should be noticed, within this context, that the term ***aT(t - T)***, in the above equation, represents the total displacement, made by the part of light emitted at the end of the rest wave period, ***T***, and traveling at a velocity of ***(c + aT)***, during an interval of time equal to ***(t -T)***, with respect to the part of light emitted at the start of the rest wave period, ***T***, and traveling at a velocity of ***c***; and hence, it reduces the wavelength, ***cT***, and leads, necessarily, to the Doppler blue shift of received light; i.e.,

$$\lambda' = cT - aT\left(t - T\right)$$

where $\boldsymbol{\lambda'}$ is the wavelength of received light, as measured in the stationary reference frame, with respect to which Einstein's elevator is mechanically accelerating.

And since the sum of the two displacements ***aT(t – T)*** & $\boldsymbol{0.5aT^2}$ is equal and opposite in its sign to the sum of the two displacements ***vT'*** & $\boldsymbol{0.5aT'^2}$, made by the mechanically accelerating elevator, during the shifted wave period, ***T'***, the two sums balance and cancel each other out; and hence, both the wave period and the frequency of received light, as measured in the accelerating reference frame of Einstein's elevator, remain unchanged and constant, as computed on the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent upon the speed of the light source; i.e.,

$$T' = T$$
$$f' = f$$

However, the flight time of light, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, is greater than the flight time of light, traveling from the floor to the ceiling of the same elevator, in the absence of mechanical acceleration:

$$\frac{c - \sqrt{c^2 - 2ah}}{a} > \frac{h}{c}$$

where ***a*** is the acceleration; and ***h*** is the height of the elevator.

In addition, at the end of the rest wave period ***T***, the velocity of light, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, is greater than the velocity of light, traveling from the floor to the ceiling of the same elevator, in the absence of mechanical acceleration; i.e.,

$$(c + aT) > c$$

where ***T*** is the rest wave period of emitted light.

And furthermore, the intensity of light, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, is less than the intensity of light, traveling from the floor to the ceiling of the same elevator, in the absence of mechanical acceleration; i.e.,

$$I\left(1 - \frac{2ah}{c^2}\right) < I$$

where ***I*** is the intensity of received light, in the absence of mechanical acceleration.

But it should be clear, however, that observers, inside Einstein's elevator, can, neither observe nor measure, in accordance with the assumption of ballistic speed of light, any amount of Doppler shift, due to the effect of mechanical acceleration on light, emitted by a light source at rest on the floor of Einstein's elevator, and received by a detector, at rest on ceiling of the same elevator.

II. In the case of light traveling from the ceiling to the floor of Einstein's elevator:

If a stationary light source, located on the ceiling, emits its light towards a stationary detector, placed on the floor of Einstein's elevator, then, on the basis of the assumption of ballistic speed of light, the total travel time of emitted light, from the ceiling to the floor of Einstein's elevator, ***t***, can be calculated by through the use of the following equation:

$$t = \frac{h - \frac{1}{2}at^2}{c} = \frac{\sqrt{c^2 + 2ah} - c}{a}$$

where ***t*** is the total travel time of light from the ceiling to the floor of Einstein's elevator; ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

And subsequently, during the travel time of light from the ceiling to the floor, Einstein's elevator, itself, along with the detector on its floor, must gain a total amount of uniform motion equals to ***v***:

$$v = at = \sqrt{c^2 + 2ah} - c$$

where ***c*** is the muzzle speed of light.

Due to the fact that the light source, during the wave period, ***T***, is accelerating in the opposite direction to the direction of emitted light, the wavelength of received light is increased by an amount equal to $0.5aT^2$; and, at the same time, the velocity of light is decreased by an amount equal to ***aT***.

And, therefore, the shifted wave period of light, ***T'***, as measured by a detector. placed at rest on the floor of Einstein's elevator, can be obtained by using this equation:

$$T' = \frac{cT + \frac{1}{2}aT^2 + aT\left(t - T\right) - vT' - \frac{1}{2}aT'^2}{c - aT} = T$$

where ***a*** is the mechanical acceleration; ***h*** is the height of Einstein's elevator; ***T*** is the rest wave period of emitted light; and ***aT(t - T)*** is calculated in accordance with this mathematical formula:

$$aT(t-T) = T\left(\sqrt{c^2+2ah}-c\right) - aT^2$$

where ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

The term ***aT(t - T)***, in the above equation, stands for the total displacement, made by the part of light emitted at the start of the rest wave period, ***T***, and traveling at a velocity of ***(c)***, during an interval of time equal to ***(t -T)***, with respect to the part of light emitted at the end of the same wave period, ***T***, and traveling with a velocity of ***(c - aT)***.

And since the sum of the two displacements ***aT(t – T)*** & $0.5aT^2$ is equal and opposite in its sign to the sum of the two displacements ***vT'*** & $0.5aT'^2$, made by the mechanically accelerating elevator, during the interval of time, ***T'***, the two sums balance and cancel each other out; and accordingly, both the wave period and the frequency of received light, with respect to the accelerating reference frame of Einstein's elevator, remain unchanged and the same, as computed on the basis of the assumption of ballistic speed of light, in accordance with which the speed of light depends upon the speed of the light source at the time of emission; i.e.,

$$T' = T$$
$$f' = f$$

where ***T*** is the rest wave period; ***T'*** is the shifted wave period; ***f*** is the rest frequency; and ***f'*** is the shifted frequency.

Nevertheless, the flight time of light, traveling from the ceiling to the floor of Einstein's elevator, in the presence of mechanical acceleration, is less than the flight time of light, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration:

$$\frac{\sqrt{c^2+2ah}-c}{a} < \frac{h}{c}$$

where ***a*** is the mechanical acceleration; and ***h*** is the height of the elevator.

Moreover, at the end of the rest wave period ***T***, the velocity of light, traveling from the ceiling to the floor of Einstein's elevator, in the presence of acceleration, is less than the velocity of light, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration; i.e.,

$$\left(c - aT\right) < c$$

where ***T*** is the rest wave period of emitted light.

And furthermore, the intensity of light, traveling from the ceiling to the floor of Einstein's elevator, in the presence of mechanical acceleration, is greater than the intensity of light, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration; i.e.,

$$I\left(1 + \frac{2ah}{c^2}\right) > I$$

where ***I*** is the intensity of received light, in the absence of mechanical acceleration.

It's to be concluded, therefore, that observers, inside Einstein's elevator, can neither observe nor measure, on the basis the assumption of the ballistic speed of light, any amount of Doppler shift, due to the effect of mechanical acceleration on light, emitted by a stationary light source, and traveling from the ceiling to the floor of Einstein's elevator.

However, in the reference frame, relative to which Einstein's elevator is mechanically accelerating, the wavelength of light emitted from the ceiling and received on the floor of Einstein's elevator, becomes a longer and red-shifted in accordance with this mathematical relation:

$$\lambda' = cT + aT\left(t - T\right)$$

where λ' is the wavelength of receive light; ***t*** is the total travel time of light, from the ceiling to the floor of the mechanically accelerating elevator; and ***aT(t - T)*** is the displacement made by light, emitted at the start of the wave period, ***T***, and traveling with the speed (***c***), with respect to light, emitted at the end of the same rest wave period, ***T***, and traveling with the speed ***(c -aT)***, and which it can be computed through the use of the following equation:

$$aT\left(t - T\right) = T\left(\sqrt{c^2 + 2ah} - c\right) - aT^2$$

where ***h*** is the height of the elevator; ***T*** is the rest wave period; and ***a*** is the mechanical acceleration of Einstein's elevator.

B. Gravitational Acceleration:

As mentioned earlier, in this discussion, it's possible, in accordance with the assumption of ballistic speed of light, to derive the equations, for calculating the effects of gravitational fields on electromagnetic radiation, directly, and without making any additional assumptions and without taking for granted any sort of equivalence between gravitational acceleration and mechanical acceleration.

Let $\boldsymbol{h}$ denote the height of the stationary elevator on Earth's surface.

And let $\boldsymbol{g}$ stand for the acceleration throughout the same elevator due to the force of gravity.

1. In the case of light traveling from the floor to the ceiling of Einstein's elevator:

If a light source, located at rest on the floor, emits its light towards a detector, placed at rest on the ceiling of Einstein's elevator, then, on the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent upon the speed of the light source, the total travel time of light emitted, at the start of the rest wave period, ***T***, can be computed by using the following equation:

$$t_1 = \frac{h + \frac{1}{2} g t_1^2}{c} = \frac{c - \sqrt{c^2 - 2gh}}{g}$$

where $\boldsymbol{t_1}$ is the travel time of light, emitted from the floor to the ceiling of Einstein's stationary elevator on Earth's surface, at the start of the rest wave period, ***T***.

And, in the same way, the total travel time of light emitted, at the end of the rest wave period, ***T***, can be calculated by the means of this equation:

$$t_2 = \frac{h + \frac{1}{2} g t_2^2}{c} = \frac{c - \sqrt{c^2 - 2gh}}{g}$$

where $\boldsymbol{t_2}$ is the total travel time of light, emitted from the floor to the ceiling of Einstein's elevator, at the end of the rest wave period, ***T***.

Accordingly, the new wave period, ***T′***, for light, emitted by a light source, at rest on the floor, and received by a Doppler-shift detector, at rest on the ceiling of Einstein's stationary elevator on Earth's surface, can be computed, in accordance with the following equation:

$$T' = T + (T_2 - T_1) = T$$

where T is the rest wave period of emitted light; and T' is the shifted wave period of received light.

And thus, the shifted frequency of received light, f', is equal to the rest frequency of emitted light, f:

$$f' = f$$

where f is the rest frequency of emitted light.

It has to be concluded, therefore, that observers, inside Einstein's elevator, on Earth's surface, can neither observe nor measure, on the basis of the assumption of ballistic speed of light, any amount of Doppler shift, due to the effect of Earth's gravitational field on light traveling from the floor to the ceiling of Einstein's elevator on Earth's surface.

Nonetheless, on the basis of the ballistic assumption, according to with which the speed of light is dependent upon the speed of the light source, the force of gravity has the following significant effects, on light traveling from the floor to the ceiling of Einstein's stationary elevator:

- The travel time of light, emitted from a light source, at rest on the floor, and received, by a detector, at rest on the ceiling of Einstein's elevator, in the presence of Earth's gravitational field, t', is greater than the travel time of light, emitted by a light source, at rest on the floor, and received, by a detector, at rest on the ceiling of the same elevator, in the absence of Earth's gravitational field:

$$t' = \frac{c - \sqrt{c^2 - 2gh}}{g} > t$$

where t is the travel time of light, emitted by a light source, at rest on the floor, and received, by a detector, at rest on the ceiling of Einstein's elevator, in the absence of the force of gravity, as calculated by using this equation:

$$t = \frac{h}{c}$$

in which ***h*** is the height of the elevator; and ***c*** is the muzzle speed of light.

- In addition, during the time of flight, from the floor to the ceiling of Einstein's stationary elevator, the received light loses a total amount of uniform motion equals to ***v***:

$$v = gt' = c - \sqrt{c^2 - 2gh}$$

where ***c*** is the muzzle speed of light.

And as a result, light, emitted by a light source, at rest on the floor, and received, by a detector, at rest on the ceiling of Einstein's elevator, has a total speed equal to ***c'***:

$$c' = c - v = \sqrt{c^2 - 2gh}$$

where ***h*** is the height of Einstein's elevator.

And so, in the presence of the force of gravity, the speed of light, emitted from a light source, at rest on the floor, and received by a detector, at rest on the ceiling of Einstein's elevator, is, always, less than the speed of light, emitted by a light source, at rest on the floor, and received, by a detector, at rest on the ceiling of the same elevator, in the absence of the force of gravity:

$$c' = c\sqrt{1 - \frac{2gh}{c^2}} < c$$

where ***g*** is the gravitational acceleration.

- The intensity of of light, emitted by a light source, at rest on the floor, and received by a detector, at rest on the ceiling of Einstein's elevator, in the presence of the force of gravity, ***I'*** is, always, less than the intensity of light, emitted by a light source, at rest on the floor, and received , by a detector, at rest on the ceiling of the same elevator, in the absence of the force of gravity; i.e.,

$$I' = I\left(1 - \frac{2gh}{c^2}\right) < I$$

where ***I*** is the intensity of light, emitted by a light source, at rest on the floor of Einstein's elevator, and received by a detector, at rest on the ceiling of the same elevator, in the absence of the force of gravity.

2. In the case of light traveling from the ceiling to the floor of Einstein's elevator:

If a light source, at rest on the ceiling, emits its light towards a detector, at rest on the floor of Einstein's elevator on Earth's surface, then, in accordance with the assumption of ballistic speed of light, on the basis of which the speed of light is dependent upon the speed of the light source, the total travel time of light emitted, at the start of the rest wave period, ***T***, can be computed through the use of the following equation:

$$t_1 = \frac{h - \frac{1}{2} g t_1^2}{c} = \frac{\sqrt{c^2 + 2gh} - c}{g}$$

where t_1 is the total travel time of light, emitted by a light source, at rest on the ceiling, towards a detector, at rest on the floor of Einstein's elevator, at the start of the rest wave period, ***T***.

And, in like manner, the total travel time of light emitted, by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, at the end of the rest wave period, ***T***, can be calculated by using this equation:

$$t_2 = \frac{h - \frac{1}{2} g t_2^2}{c} = \frac{\sqrt{c^2 + 2gh} - c}{g}$$

where t_2 is the total travel time of light, emitted by a light source, at rest on the ceiling, towards a detector, at rest on the floor of Einstein's elevator, at the end of the rest wave period, ***T***.

And subsequently, the shifted wave period, ***T′***, for light, emitted by a light source, at rest on the ceiling, and received by a Doppler-shift detector, at rest on the floor of Einstein's stationary elevator on Earth's surface, can be calculated, according to the following equation:

$$T' = T + (T_2 - T_1) = T$$

where $\boldsymbol{T}$ is the rest wave period of emitted light; and $\boldsymbol{T'}$ is the shifted wave period of received light.

And, as a consequence, the shifted frequency of received light, $\boldsymbol{f'}$, is equal to the rest frequency of emitted light, $\boldsymbol{f}$; i.e.,

$$f' = f$$

where $\boldsymbol{f}$ is the rest frequency of emitted light; and $\boldsymbol{f'}$ is the shifted frequency of received light.

And we must conclude, therefore, that observers, inside Einstein's elevator, can neither observe nor measure, in accordance with the assumption of ballistic speed of light, any amount of Doppler shift, due to the effect of Earth's gravitational gravitational field on light, emitted by a stationary light source, and traveling from the ceiling to the floor of Einstein's elevator.

However, on the basis of the ballistic assumption, according to which the speed of light is dependent on the speed of the light source, the force of gravity has the following effects, on light, emitted by a stationary light source, and traveling from the ceiling to the floor of Einstein's elevator:

- The total travel time of light, emitted by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, in the presence of the force of gravity, $\boldsymbol{t'}$, is less than the travel time of light, emitted by a stationary light source, placed on the ceiling, and received by a stationary detector, located on the floor of the same elevator, in the absence of the force of gravity; i.e.,

  $$t' = \frac{\sqrt{c^2 + 2gh} - c}{g} < t$$

  where $\boldsymbol{t}$ is the total travel time of light, emitted by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, in the absence of the force of gravity, as computed by this formula:

  $$t = \frac{h}{c}$$

where ***c*** is the muzzle speed of light.

- Light, emitted by a stationary light source, during its total travel time, from the ceiling to the floor of Einstein's elevator, must gain a total amount of uniform motion, with respect to the reference frame of the same elevator, equals to ***v***:

$$v = gt' = \sqrt{c^2 + 2gh} - c$$

where ***g*** is the gravitational acceleration.

And accordingly, light, emitted by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator on Earth's surface, travels at a total speed equal to ***c'***:

$$c' = c + v = \sqrt{c^2 + 2gh}$$

where ***h*** is the height of Einstein's elevator.

And, subsequently, in the presence of the force of gravity, the speed of light, emitted by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, is, always, greater than the speed of light, emitted by a light source, at rest on the ceiling and received by detector, at rest on the floor of the same elevator, in the absence of the force of gravity:

$$c' = c\sqrt{1 + \frac{2gh}{c^2}} > c$$

where ***g*** is the gravitational acceleration.

- The intensity of of light, emitted by a stationary light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, in the presence of the force of gravity, ***I'*** is, always, greater than the intensity of light, emitted by the same light source on ceiling, and received by the same detector on the floor of the same elevator, in the absence of the force of gravity; i.e.,

$$I' = I\left(1 + \frac{2gh}{c^2}\right) > I$$

where I is the intensity of light, emitted by a light source, at rest on the ceiling, and received by a detector, at rest on the floor of Einstein's elevator, in the absence of the force of gravity.

It should be clear, from the quantitative treatment, above, that, according to the assumption of ballistic speed of light, on the basis of which the speed of light is dependent on the speed of the light source, gravitational acceleration and mechanical acceleration are equivalent to each other, with regard to their effects on light, emitted by a stationary light source, and received by a stationary detector, as observed in the reference frame, in which Einstein's elevator is at rest.

The aforementioned equivalence between gravitational acceleration and mechanical acceleration, in accordance with the assumption of ballistic speed of light, however, unlike Einstein's principle of equivalence, does not alter the rest wave periods and the rest frequencies of electromagnetic radiation, in the case, in which the source of electromagnetic radiation is at rest with respect to the reference frame, in which Einstein's elevator is at rest, in any shape or form, at all.

In the following section, the effects of mechanical acceleration as well as the effects of gravitational acceleration, on particle beams traveling both ways, inside Einstein's elevator, will be analyzed and discussed in detail, in order to find out whether there is any significant differences, in this regard, between the above quantitative treatment of beams of electromagnetic radiation and the quantitative treatment of beams of particles, and beams of projectiles, in general, on the basis of the ballistic assumption, according which the motion of the beam depends, necessarily, upon the motion of the beam source.

4. Replacing Electromagnetic Radiation with Particle Beams:

First and foremost, it's obvious, at first glance, that no quantitative treatment of particle beams, on the basis of the assumption of constant beam speed along with Einstein's principle of equivalence, is, theoretically, viable, here, or possible, in any way; since the assumption of constant beam speed, in the case of particle beams, can never be made, to begin with, or, somehow, put forward, at all.

And therefore, only the ballistic assumption will be applied to the case under investigation.

But, is it, practically, feasible to replace the beam of electromagnetic radiation, inside Einstein's elevator, with a beam of particles, such as a beam of bullets, for example?

Well, Einstein's elevator is supposed to be a '*Gedankenexperiment*', anyway; however, provided that the proper procedures have been followed and applied, correctly, it should be possible, in practice, to replace beams of electromagnetic radiation, inside Einstein's elevator, with beams of bullets, beams of atoms, beams of ions, or beams of any other kind of projectiles [***Ref. #9a***].

But nonetheless, in the case of beams of bullets, beams of particles, and beams of projectiles, in general, the speed of every bullet, particle, or projectile, in the beam, must depend upon the speed of its source; and hence, the assumption, according to which the speed of the beam is independent of the speed of the beam source, does not apply to any of those cases.

And so, now, the most relevant question, here, ought to be this:

Are there, inside Einstein's elevator, any measurable differences between the effects of mechanical acceleration and the effects of gravitational acceleration, during the time of propagation, on the aforementioned bullet beam, and the effects of mechanical acceleration and gravitational acceleration, during the time of propagation, on the electromagnetic beam, as analyzed earlier in this discussion?

To answer, in a quantitative manner, the above question, let's press ahead and apply the ballistic assumption, in accordance with which the speed of the beam is dependent upon the speed of the beam source, to the propagation of a chronologically ordered and spatially collimated beam of bullets, inside a mechanically accelerating elevator, and inside a stationary elevator on Earth's surface, respectively.

A. In the Case of Mechanically Accelerating Elevators:

Let the bullet source fire its bullets, in sequence, at a constant interval of time equal to T.

Let h denote the height of the elevator in outer space.

And let a stand for the acceleration of the same elevator due to a mechanical force.

And let c stand for the muzzle speed of the bullet bean.

And let f stand for the temporal frequency of the bullet beam.

And, now, these are the two main scenarios for the propagation of the bullet beam, inside an elevator uniformly accelerating, under the effect of a mechanical force:

1. **The bullets traveling from the floor to the ceiling of Einstein's elevator:**

If a stationary bullet source, located on the floor, fires its bullets, sequentially, at a constant interval of time, T, towards a stationary detector on the ceiling of Einstein's elevator, then, on the basis of the ballistic assumption, according to which the speed of the bullet is dependent upon the speed of its source, the total travel time of a bullet fired at the start of, the rest beam period, T, can be computed through the use of the following equation:

$$t = \frac{h + \frac{1}{2}at^2}{c} = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

where ***t*** is the total travel time of the bullet from the floor to the ceiling of Einstein's elevator; ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

And consequently, during the travel time of the bullet from the floor to the ceiling, the mechanically accelerating elevator gains a total amount of uniform motion, relative to the bullet beam, equals to ***v***:

$$v = at = c - \sqrt{c^2 - 2ah}$$

where ***c*** is the muzzle speed of the fired bullet.

In the meantime, the speed of the bullet relative to the ceiling of the mechanically accelerating elevator, ***c'***, is reduced, in accordance with this equation:

$$c' = c - v = \sqrt{c^2 - 2ah} = c\sqrt{1 - \frac{2ah}{c^2}}$$

where ***a*** is the mechanical acceleration.

And therefore, if the linear momentum of the bullet, relative to the floor of the elevator, is equal to ***p***, then its linear momentum, relative to the ceiling of the elevator, ***p'***, can be calculated by using this equation:

$$p' = p\left[\sqrt{1 - \frac{2ah}{c^2}}\right]$$

where ***h*** is the height of Einstein's elevator.

And likewise, if the kinetic energy of the bullet, with respect to the floor, is equal to ***E***, then its kinetic energy, with respect to the ceiling of the mechanically accelerating elevator, ***E'***, can be obtained through the use of the following equation:

$$E' = E\left[1 - \frac{2ah}{c^2}\right]$$

where ***a*** is the mechanical acceleration of Einstein's elevator.

And furthermore, due to the fact that the bullet source, during the rest beam period, ***T***, is accelerating in the same direction as that of the bullet beam — the spatial frequency of the bullet beam — the distance between each pair of bullets, ***cT***, is decreased by an amount equal to the displacement, $\boldsymbol{0.5aT^2}$; while, at the same time, the bullet velocity, at the end of the rest beam period, ***T***, is increased by an amount equal to ***aT***.

And, therefore, the new beam period, ***T'***, as measured by a detector, placed at rest on the ceiling of Einstein's elevator, can be computed by the means of this equation:

$$T' = \frac{cT - \frac{1}{2}aT^2 - aT\left(t - T\right) + vT' + \frac{1}{2}aT'^2}{c + aT} = T$$

where ***a*** is the mechanical acceleration; ***h*** is the height of the elevator; ***T*** is the rest beam period; and ***aT(t - T)*** is the displacement that the trailing bullet, traveling with the velocity, ***(c + aT)***, makes, relative to the leading bullet, traveling with the velocity, ***(c)***, during the travel time of the bullet from the floor to the ceiling, ***t***, and which can be calculated in accordance with the following equation:

$$aT\left(t - T\right) = T\left(c - \sqrt{c^2 - 2ah}\right) - aT^2$$

where ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

As defined, above, the term ***aT(t - T)***, in the above equation, represents the total displacement, made by the bullet fired at the end of the rest beam period, ***T***, and traveling at a velocity of ***(c + aT)***, during an interval of time equal to ***(t -T)***, with respect to the bullet fired at the start of the rest beam period, ***T***, and traveling at a velocity of ***c***.

And it should be emphasized, within the current context, that the aforementioned displacement, ***aT(t - T)***, is, by far, the most important mathematical term, in computational formulas of Doppler effect, based upon the ballistic assumption, and the single most significant factor behind the theoretical and the practical impossibility of detecting any amount of Doppler shift, in any kind of beams, due to mechanical acceleration, with respect to mechanically accelerating frames of references, in general.

Anyway, since the sum of the two displacements $aT(t - T)$ & $0.5aT^2$ is the additive inverse of the sum of the two displacements vT' & $0.5aT'^2$, made by the mechanically accelerating elevator, during the shifted beam period, T', the two sums balance and cancel each other out; and accordingly, both the rest beam period and the rest temporal frequency of the bullet beam, as measured in the mechanically accelerating reference frame of Einstein's elevator, remain unchanged and constant, as computed in accordance with the ballistic assumption. That is on one hand.

On the other hand, however, because the detector is accelerating away from the bullet beam, the flight time of bullets, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, is greater than the flight time of bullets, traveling from the floor to the ceiling of the same elevator, in the absence of mechanical acceleration; i.e.,

$$\frac{c-\sqrt{c^2-2ah}}{a} > \frac{h}{c}$$

where a is the mechanical acceleration; and h is the height of the elevator.

In addition, at the end of the rest beam period T, the velocity of bullets, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, is greater than the velocity of bullets, traveling from the floor to the ceiling of the same mechanically accelerating elevator, in the absence of mechanical acceleration; i.e.,

$$\left(c+aT\right) > c$$

where T is the rest beam period of fired bullets; and c is the muzzle speed of the fired bullet.

And furthermore, the linear momentum and the kinetic energy of bullets, traveling from the floor to the ceiling of Einstein's elevator, in the presence of mechanical acceleration, are less than the linear momentum and the kinetic energy of bullets, traveling from the floor to the ceiling of the same elevator, in the absence of mechanical acceleration; i.e.,

$$p' = p\left[\sqrt{1-\frac{2ah}{c^2}}\right] < p$$

where p is the linear momentum of bullets, relative to the ceiling, in the absence of mechanical acceleration; and, also:

$$E' = E\left[1 - \frac{2ah}{c^2}\right] < E$$

where ***E*** is the kinetic energy of bullets, relative to the ceiling of Einstein's elevator, in the absence of mechanical acceleration.

And so, now, in the reference frame, with respect to which Einstein's elevator is accelerating, is it possible for the bullet beam, under investigation, to show any amount of Doppler blue shift?

There can be no doubt that, on the basis of the ballistic assumption, it's possible, in principle, to measure, within the reference frame, relative to which Einstein's elevator is accelerating, the Doppler blue shift, in the received beam period, ***T'***, as well as, in the received temporal frequency, ***f'***, for the bullet beam, in question.

And this, briefly, how, based on the ballistic assumption, the above proposition is demonstrated:

Let ***T*** stand for the rest beam period of the flying bullets.

And let ***a*** denote the mechanical acceleration of Einstein's elevator.

Because a bullet fired at the end of the rest beam period, ***T***, is moving with the velocity resultant, ***(c + aT)***, relative to a bullet fired at the start of the same beam period, ***T***, and moving with the muzzle velocity, ***c***, the spatial frequency of the bullet beam, ***cT***, is reduced, continually, in inverse proportion to the bullet time of flight, ***t***; i.e.,

$$\lambda' = cT - aT\left(t - T\right)$$

where ***λ'*** is the shifted spatial frequency of the bullet beam.

And by simply inserting into the above formula this value of ***t***:

$$t = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

it can be seen, at once, that the bullet beam, under discussion, is blue-shifted, as observed from the reference frame, with respect to which Einstein's elevator is mechanically accelerating.

But let's, here, assume, for a moment, that the bullet beam, in question, is allowed to escape from Einstein's elevator and to travel, inertially, in a perfect vacuum, forever.

Will the temporal frequency of the aforementioned bullet beam, in that case, eventually, become, at some point along its inertial path, infinitely blue-shifted?

Clearly, in the above hypothetical scenario, the spatial frequency, λ', will reach the value of ***0***, immediately, after the elapse of an interval of time, since the firing, equal to t_{max}:

$$t_{\max} = \frac{c}{a} + T$$

where ***c*** is the muzzle speed of the bullet beam; and ***a*** is the mechanical acceleration of the bullet source at the time of firing.

And accordingly, at the end of the interval of time, t_{max}, if the cross section of the bullet beam is, sufficiently, larger than the size of the fired bullet, the two bullets will, momentarily, travel, together, side by side, and the temporal frequency of the bullet beam will turn, at once, into intensity.

In consequence, right away, after the instant of the end of t_{max}, the slower bullet, traveling with the muzzle velocity ***c***, will begin receding further and further from the faster bullet, traveling with the velocity resultant $(c + aT)$; and as result, the spatial frequency of the bullet beam, λ', starts to increase, indefinitely, in direct proportion to the bullet time of flight, since the end of t_{max}, in accordance with this mathematical formula:

$$\lambda' = aT\left[t - \left(\frac{c}{a} + T\right)\right]$$

where ***t*** is the total interval of time, elapsed since the firing; ***T*** is the rest beam period; and ***a*** is the mechanical acceleration of the bullet source at the time of firing.

And so, it's obvious, from the above equation, that the shifted beam period, T', will increase, in direct proportion, indefinitely; and the shifted temporal frequency, f', will decrease, in inverse proportion, to the bullet time of flight, since the end of t_{max}, indefinitely, as well.

2. The bullets traveling from the ceiling to the floor of Einstein's elevator:

If a stationary bullet source, located on the ceiling, fires its bullet towards a stationary detector, placed on the floor of Einstein's elevator, then, in accordance with the ballistic assumption, the total travel time of a bullet fired at the start of the rest beam period, ***T***, can be obtained from the following equation:

$$t = \frac{h - \frac{1}{2}at^2}{c} = \frac{\sqrt{c^2 + 2ah} - c}{a}$$

where ***t*** is the total travel time of a fired bullet from the ceiling to the floor of Einstein's elevator; ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

And moreover, during the travel time of the flying bullet from the ceiling to the floor, Einstein's elevator, itself, will gain a total amount of uniform motion equals to ***v***:

$$v = at = \sqrt{c^2 + 2ah} - c$$

where ***c*** is the muzzle speed of the bullet.

And as a consequence, the speed of the flying bullet relative to the floor of Einstein's elevator must be equal to ***c′*** :

$$c' = c + v = \sqrt{c^2 + 2ah} = c\sqrt{1 + \frac{2ah}{c^2}}$$

where ***h*** is the height of Einstein's elevator.

And therefore, if the linear momentum of the bullet, relative to the ceiling of the elevator, is equal to ***p***, then its linear momentum, relative to the floor of the same elevator, ***p′***, can be calculated by making use of this equation:

$$p' = p\left[\sqrt{1 + \frac{2ah}{c^2}}\right]$$

where ***a*** is the mechanical acceleration of Einstein's elevator.

And, in the same way, if the kinetic energy of the flying bullet, with respect to the ceiling, is equal to ***E***, then its kinetic energy, with respect to the floor of Einstein's elevator, ***E′***, can be obtained by using the following equation:

$$E' = E\left[1 + \frac{2ah}{c^2}\right]$$

where ***h*** is the height of Einstein's elevator.

Due to the fact that the bullet source, during the beam period, ***T***, is accelerating in the opposite direction to that of the fired bullets, the spatial frequency — i.e., the distance between each pair of bullets, ***cT*** — is increased by an amount equal to the displacement, $0.5aT^2$; while, at the same time, the velocity of the trailing bullet is decreased, relative to that of the leading bullet, by an amount equal to ***aT***.

And, therefore, the new period of the bullet beam, ***T'***, as measured by a detector, placed at rest on the floor of Einstein's elevator, can be calculated through the use of this equation:

$$T' = \frac{cT + \frac{1}{2}aT^2 + aT\left(t - T\right) - vT' - \frac{1}{2}aT'^2}{c - aT} = T$$

where ***a*** is the mechanical acceleration; ***h*** is the height of the elevator; ***T*** is the rest beam period of fired bullets; and ***aT(t - T)*** is calculated in accordance with the following formula:

$$aT\left(t - T\right) = T\left(\sqrt{c^2 + 2ah} - c\right) - aT^2$$

where ***h*** is the height of the elevator; and ***a*** is the mechanical acceleration.

The term, ***aT(t - T)***, in the above equation, stands for the total displacement, made by a bullet fired at the start of the beam period, ***T***, and traveling at a velocity of ***(c)***, during an interval of time equal to ***(t -T)***, with respect to a bullet fired at the end of the beam period, ***T***, and traveling with the velocity resultant, ***(c - aT).***

Since the sum of the two displacements ***aT(t – T)*** & $0.5aT^2$ is equal and opposite in its sign to the sum of the two displacements ***vT'*** & $0.5aT'^2$, made by the mechanically accelerating elevator, during the interval of time, ***T'***, the two sums balance and cancel each other out; and as a result, both the rest beam period and the rest temporal frequency of the bullet beam, as measured in the reference frame, in which Einstein's elevator is at rest, remain unchanged and the same, as computed on the basis of the ballistic assumption.

However, because the detector is accelerating towards the bullet beam, the flight time of bullets, traveling from the ceiling to the floor of Einstein's elevator, in the presence of mechanical acceleration, is less than the flight time of the same bullets, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration:

$$\frac{\sqrt{c^2+2ah}-c}{a}<\frac{h}{c}$$

where $\boldsymbol{a}$ is the mechanical acceleration; and $\boldsymbol{h}$ is the height of the elevator.

In addition, at the end of the rest wave period, $\boldsymbol{T}$, the velocity of bullets, traveling from the ceiling to the floor of Einstein's elevator, in the presence of mechanical acceleration, is less than the velocity of bullets, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration; i.e.,

$$(c-aT)<c$$

where $\boldsymbol{T}$ is the rest period of the bullet beam.

And furthermore, the linear momentum and the kinetic energy of bullets, flying from the ceiling to the floor of Einstein's elevator, in the presence of mechanical acceleration, are greater than the linear momentum and the kinetic energy of bullets, traveling from the ceiling to the floor of the same elevator, in the absence of mechanical acceleration; i.e.,

$$p'=p\left[\sqrt{1+\frac{2ah}{c^2}}\right]>p$$

where $\boldsymbol{p}$ is the linear momentum of bullets, relative to the floor, in the absence of mechanical acceleration;

and the kinetic energy, $\boldsymbol{E'}$:

$$E'=E\left[1+\frac{2ah}{c^2}\right]>E$$

where $\boldsymbol{E}$ is the kinetic energy of fired bullets, relative to the floor of the elevator, in the absence of mechanical acceleration.

But, once again, is it possible, from a theoretical perspective, in the reference frame, relative to which Einstein's elevator is accelerating, for the bullet beam, under investigation, to exhibit a certain amount of Doppler red shift?

It's quite obvious that calculations, based on the ballistic assumption, carried out in the reference frame, with respect to which Einstein's elevator is mechanically accelerating, predict significant amounts of Doppler red shift, in the received beam period, ***T'***, as well as, in the received temporal frequency, ***f'***, for the bullet beam, under discussion:

Let ***T*** stand for the rest beam period of the flying bullets.

And let ***a*** stand for the mechanical acceleration of Einstein's elevator.

Since a bullet, fired at the end of the rest beam period, ***T***, is traveling at the velocity resultant, ***(c - aT)***, with respect to a bullet, fired at the start of the same rest beam period, ***T***, and traveling at the muzzle velocity, ***c***, the spatial frequency of the bullet beam, ***cT***, gets longer and longer, indefinitely, in direct proportion to the bullet time of flight since firing, ***t***; i.e.,

$$\lambda' = cT + aT\left(t - T\right)$$

where ***λ'*** is the shifted spatial frequency of the bullet beam.

And so, by simply inserting into the above formula this value of ***t***:

$$t = \frac{\sqrt{c^2 + 2ah} - c}{a}$$

it can be concluded, immediately, that the bullet beam, under discussion, must be red-shifted, as measured in the reference frame, relative to which Einstein's elevator is mechanically accelerating.

And, finally, let's apply the assumption, in accordance with which the speed of the beam is dependent on the speed of the beam source, to the propagation of a chronologically ordered and highly organized beam of bullets, inside a stationary elevator in the gravitational field of the earth.

B. In the Case of Stationary Elevators in Earth's Gravitational Field:

Let ***h*** denote the height of the stationary elevator.

And let ***g*** stand for the gravitational acceleration on Earth's surface.

And let ***c*** stand for the muzzle speed of the bullet bean.

And let f stand for the temporal frequency of the bullet beam.

And finally, let the bullet source fire one bullet every interval of time equal to T.

And so, now, these are the two major cases, under investigation:

I. The bullets traveling from the floor to the ceiling of a Stationary elevator:

If a stationary bullet source, located on the floor, fires its bullets towards a stationary detector, placed on the ceiling of an elevator, at rest on Earth's surface, then, in accordance with the ballistic assumption, on the basis of which the speed of the bullet is dependent upon the speed of its source, the total travel time of a bullet fired at the start of, the beam period, T, can be computed by inserting the required numerical data into the following equation:

$$t = \frac{h + \frac{1}{2}gt^2}{c} = \frac{c - \sqrt{c^2 - 2gh}}{g}$$

where t is the total travel time of the fired bullet from the floor to the ceiling of the stationary elevator; h is the height of the same elevator; and g is the gravitational acceleration on Earth's surface..

And subsequently, during the travel time of the bullet from the floor to the ceiling of the stationary elevator, the bullet, itself, must lose a total amount of uniform motion equals to v:

$$v = gt = c - \sqrt{c^2 - 2gh}$$

where c is the muzzle speed of the fired bullet.

And as a result, the speed of the fired bullet, with respect to the ceiling of the stationary elevator on Earth's surface, is equal to c':

$$c' = c - v = \sqrt{c^2 - 2gh} = c\sqrt{1 - \frac{2gh}{c^2}}$$

where g is the gravitational acceleration on Earth's surface.

And therefore, if the linear momentum of the flying bullet, relative to the floor of the stationary elevator, is equal to p, then its linear momentum, with respect to the ceiling of the same elevator, p', can be computed through the use of the following equation:

$$p' = p\left(\sqrt{1-\frac{2gh}{c^2}}\right)$$

where h is the height of Einstein's elevator.

And similarly, if the kinetic energy of the fired bullet, with respect to the floor of the stationary elevator, is equal to E, then its kinetic energy, relative to the ceiling of the same stationary elevator, E', can be obtained by the means of this equation:

$$E' = E\left(1-\frac{2gh}{c^2}\right)$$

where g is the strength of the gravitational field inside the stationary elevator.

And since the fired bullet, during the rest bullet period, T, is decelerating in the same direction of the bullet beam, the distance between each pair of bullets, cT, is decreased by an amount equal to $0.5aT^2$.

And, therefore, the shifted beam period, T', as measured by a detector at rest on the ceiling of the stationary elevator on Earth's surface, can be calculated by using this equation:

$$T' = \frac{cT - \frac{1}{2}gT^2 + \frac{1}{2}gT'^2}{c} = \frac{c-\sqrt{c^2 - 2g\left(cT - \frac{1}{2}gT^2\right)}}{g} = T$$

where g is the gravitational acceleration; h is the height of the elevator; and T is the rest period of the bullet beam.

It follows, therefore, that both the rest beam period and the rest temporal frequency of the bullet beam, as measured in the reference frame of an elevator, at rest on Earth's surface, must remain unchanged and constant, as calculated on the basis of the ballistic assumption.

Nevertheless, the linear momentum and the kinetic energy of fired bullets, traveling from the floor to the ceiling of the stationary elevator, in the presence of the gravitational acceleration, ***g***, is less than the linear momentum and the kinetic energy of fired bullets, traveling from the floor to the ceiling of the same elevator, in the absence of gravitational acceleration; i.e.,

$$p' = p\left(\sqrt{1-\frac{2gh}{c^2}}\right) < p$$

where ***p*** is the linear momentum of flying bullets, relative to the ceiling of the stationary elevator, in the absence of any gravitational field.

$$E' = E\left(1-\frac{2gh}{c^2}\right) < E$$

where ***E*** is the kinetic energy of flying bullets, relative to the ceiling of the stationary elevator, in the absence of gravitational acceleration.

II. The bullets traveling from the ceiling to the floor of a Stationary elevator:

If a stationary bullet source, placed on the ceiling, fires its bullets towards a stationary detector, located on the floor of an elevator, at rest on Earth's surface, then, according to the ballistic assumption, on the basis of which the speed of the bullet is dependent upon the speed of the bullet source, the total travel time of a bullet, fired at the start of the rest beam period, ***T***, can be computed by inserting the necessary numerical data into the following equation:

$$t = \frac{h - \frac{1}{2}gt^2}{c} = \frac{\sqrt{c^2 + 2gh} - c}{g}$$

where ***t*** is the total travel time of the bullet from the ceiling to the floor of the stationary elevator; ***h*** is the height of the same elevator; and ***g*** is the gravitational acceleration on Earth's surface.

And correspondingly, during the flight time of the bullet from the ceiling to the floor of the stationary elevator, the flying bullet will have to gain a total amount of uniform motion equals to ***v***:

$$v = gt = \sqrt{c^2 + 2gh} - c$$

where ***c*** is the muzzle speed of the bullet.

And subsequently, the speed of the bullet relative to the floor of the stationary elevator is equal to ***c′***:

$$c' = c + v = \sqrt{c^2 + 2gh} = c\sqrt{1 + \frac{2gh}{c^2}}$$

where ***h*** is the height of the stationary elevator.

And therefore, if the linear momentum of the flying bullet, relative to the ceiling of the stationary elevator, is equal to ***p***, then its linear momentum, relative to the floor of the same elevator, ***p′***, can be computed by inserting the required data into the following equation:

$$p' = p\left(\sqrt{1 + \frac{2gh}{c^2}}\right)$$

where ***g*** is the gravitational acceleration throughout the stationary elevator.

And, in a similar manner, if the kinetic energy of the fired bullet, with respect to the ceiling of the stationary elevator, is equal to ***E***, then its kinetic energy, with respect to the floor of the same stationary elevator, ***E′***, can be obtained by the means of this equation:

$$E' = E\left(1 + \frac{2gh}{c^2}\right)$$

where ***c*** is the muzzle speed of fired bullets.

Since the flying bullet, during the rest beam period, ***T***, is accelerating in the same direction to that of the bullet beam, the spatial frequency — i.e., the distance between each pair of bullets, ***cT***, is increased by an amount equal to the displacement, $0.5aT^2$.

And, therefore, the shifted beam period, ***T′***, as measured by a detector at rest on the floor of the stationary elevator, can be calculated by using this equation:

$$T' = \frac{cT + \frac{1}{2}gT^2 - \frac{1}{2}gT'^2}{c} = \frac{\sqrt{c^2 + 2g\left(cT + \frac{1}{2}gT^2\right)} - c}{g} = T$$

where g is the gravitational acceleration; h is the height of the stationary elevator; and T is the rest beam period.

And it follows, as a result, that the rest beam period and the rest temporal frequency of a bullet beam traveling, from the ceiling to the floor of the stationary elevator, on Earth's surface, remain unchanged and constant, as computed on the basis of the ballistic assumption.

Nonetheless, the linear momentum of fired bullets, traveling from the ceiling to the floor of the stationary elevator, in the presence of gravitational acceleration, is greater than the linear momentum of bullets, traveling from the ceiling to the floor of the same stationary elevator, in the absence of any gravitational acceleration:

$$p' = p\left(\sqrt{1 + \frac{2gh}{c^2}}\right) > p$$

where p is the linear momentum of fired bullets, with respect to the floor of the stationary elevator, in the absence of gravitational acceleration.

And, in the same way, the kinetic energy of fired bullets, traveling from the ceiling to the floor of the stationary elevator, in the presence of gravitational acceleration, is greater than the kinetic energy of bullets, traveling from the ceiling to the floor of the same elevator, in the complete absence of any gravitational acceleration:

$$E' = E\left(1 + \frac{2gh}{c^2}\right) > E$$

where E is the kinetic energy of flying bullets, relative to the floor of the stationary elevator, in the absence of gravitational acceleration.

And we have to conclude, therefore, that, in all of the cases, in which the beam source and the beam detector are at rest relative to each other and relative to the gravitational field, in question, no amount of any Doppler shift, in the beam periods, as well as, in the beam temporal frequencies of any kind of particle beams, can be observed, measured, or detected, even in principle, from any frame of reference, or predicted, in advance, in any way, based on any calculations carried out in accordance with the ballistic assumption, on the basis of which the speed of the beam is dependent upon the speed of the beam source.

5. The Experimental Result on the Assumption of Constant Speed of Light:

As pointed out already, in this discussion, the mathematical formulas, for calculating Einstein's gravitational redshift, cannot be derived, directly, because, on the assumption of constant speed of light, according to which the speed of light is independent of the speed of the light source, gravitational fields are not allowed, theoretically, to accelerate any part of the electromagnetic spectrum, in any conceivable way, under any circumstances.

And consequently, Einstein's principle of equivalence, in accordance with which the effect of mechanical acceleration and the effect of gravitational acceleration, on electromagnetic radiation, are the same and equivalent to each other, has to be employed in deriving the following equation, for computing Einstein's gravitational redshift, in the case of rising electromagnetic radiation whose emitting source is at rest, relative to the Doppler-shift detector and relative to the gravitational field:

$$z = \frac{f - f'}{f} = 1 - \frac{g/f}{\sqrt{c^2 - 2gh} - \sqrt{(c - gT)^2 - 2gh}}$$

where z is Einstein's gravitational redshift; and g is the gravitational acceleration.

and also, in deriving this equation, for computing the gravitational blue shift, in the case of falling electromagnetic radiation whose source is at rest with respect to the detector and the gravitational field:

$$z = \frac{f' - f}{f} = \frac{g/f}{\sqrt{(c + gT)^2 + 2gh} - \sqrt{c^2 + 2gh}} - 1$$

where z is Einstein's gravitational blue shift, due to the effect of the force of gravity; and T is the rest wave period of emitted light.

However, in the Pound-Rebka Experiment, the gamma-ray source is moving, in the opposite direction to that of the gravitational acceleration, g, with a varying speed, v, which has an optimal value that can be determined, in advance, through the use of the following equation:

$$v \approx \frac{gh}{c} = 7.36 \times 10^{-7} \quad \text{ms}^{-1}$$

where ***g*** is the gravitational acceleration; and ***h*** is the vertical distance between the gamma-ray source and the gamma-ray absorber.

And so, it's necessary, within the current context, to derive the relevant equations, for computing the effect of gravitational acceleration, on electromagnetic radiation, emitted by a moving source, through the application of Einstein's principle of equivalence, in the case of rising electromagnetic radiation, and in the case of falling electromagnetic radiation, respectively.

A. In the Case of Rising Electromagnetic Radiation:

Let ***h*** denote the height of the elevator in outer space.

& let ***a*** denote the acceleration of the same elevator due to a mechanical force.

If a light source, moving with a speed, ***v***, from the floor towards the ceiling of Einstein's elevator, emits its light towards a stationary Doppler-shift detector, located on the ceiling of the same elevator, then, in the reference frame, in which the mechanically accelerating elevator is at res, the total travel time of light, emitted at the start of the rest wave period, ***T***, can be obtained, on the basis of the assumption of constant speed of light, according to which the speed of light is independent of the speed of the light source, through the use of the following mathematical formula:

$$t_1 = \frac{h + \frac{1}{2} a t_1^2}{c} = \frac{c - \sqrt{c^2 - 2ah}}{a}$$

where t_1 is the total travel time of light, emitted, by a moving light source at the start of the rest wave period, ***T***, and traveling with the speed ***c***, from the floor to the ceiling of the mechanically accelerating elevator.

And likewise, the total travel time of light, emitted, by the same moving light source, at the end of the same rest wave period, ***T***, can be obtained by using the following equation:,

$$t_2 = \frac{h - vT + \frac{1}{2}aT^2 + aTt_2 + \frac{1}{2}at_2^2}{c} = \frac{(c - aT) - \sqrt{c^2 - 2ah - 2aT(c - v)}}{a}$$

where **t_2** is the total travel time of light, emitted, by a moving light source, at the end of the rest wave period, **T**, and traveling with the speed **c**, from the floor to the ceiling of Einstein's mechanically accelerating elevator.

And thus, it follows, immediately, that the new wave period, **T'**, can be computed through the use of the this equation:

$$T' = T + (t_2 - t_1) = \frac{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2aT(c - v)}}{a}$$

where **T'** is the shifted wave period, for light, emitted by a moving light source, towards a detector at rest on the ceiling of a mechanically accelerating elevator.

In addition, during the travel time of light, from the floor to the ceiling, the mechanically accelerating elevator, necessarily, will have to gain an mount of uniform speed, **v'**, relative to the emitted light:

$$v' = aT' = \sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2aT(c - v)}$$

where **a** is the mechanical acceleration.

And correspondingly, the shifted frequency of received light, **f'**, is given by this equation:

$$f' = \frac{1}{T'} = \frac{a}{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2aT(c - v)}}$$

where **v** is the speed of the light source.

And therefore, the combined value of the Doppler blue shift, caused by the motion of the light source, and the Doppler red shift, due to mechanical acceleration, **z**, for light traveling from the floor to the ceiling of the mechanically accelerating elevator, as predicted, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source, can be computed by the means of the following equation:

$$z = \frac{f - f'}{f} = 1 - \frac{a/f}{\sqrt{c^2 - 2ah} - \sqrt{c^2 - 2ah - 2aT\left(c - v\right)}}$$

where ***f*** is the rest frequency of emitted light; and ***f'*** is the shifted frequency of received light.

And it follows, therefore, that, by applying Einstein's principle of equivalence between mechanical acceleration and gravitational acceleration, to the stationary elevator, on Earth's surface, we can obtain the following formula, for calculating the combined Doppler shift of light, emitted by a moving source, and traveling from the floor to the ceiling of the same elevator, under the effect of the force of gravity:

$$z = \frac{f - f'}{f} = 1 - \frac{g/f}{\sqrt{c^2 - 2gh} - \sqrt{c^2 - 2gh - 2gT\left(c - v\right)}}$$

where ***z*** is the combined value of the Doppler blue shift, due to the motion of the gamma-ray source, and Einstein's gravitational redshift, due to the effect of Earth's gravitational field on light traveling from the floor to the ceiling of the stationary elevator; ***f*** is the rest frequency; and ***T*** is the wave rest period of emitted light.

And accordingly, we can, now, obtain the predicted combined value of the Doppler blue shift, due to the motion of the gamma-ray source, and Einstein's gravitational redshift, due to Earth's gravitational acceleration, on rising gamma rays, emitted by a moving source, and traveling from the floor to the ceiling of Einstein's stationary elevator, and the equivalent uniform velocity, by inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a*** **&** ***Ref. #2***], into the above equation:

$$c = 299792458 \ \text{ms}^{-1}$$
$$g = 9.80665 \ \text{ms}^{-2}$$
$$h = 22.5 \ \text{m}$$
$$f = 3.46 \times 10^{18} \ \text{Hz}$$
$$v = 7.36 \times 10^{-7} \ \text{ms}^{-1}$$

And, here, it's, highly, recommended to use a high precision calculator, in the present calculations, in order to get rid of the rounding errors of floating points and the catastrophic cancellations, in quadratic formulas [***Ref. #5***].

The following numerical results are obtained, through the use of the desktop calculator, ***SpeedCrunch***

0.12 (Portable Edition), with its precision set to ***50*** digits:

$$z = 1.060504861497 \times 10^{-25}$$
$$v'' = +3.179313591 \times 10^{-17} \text{ ms}^{-1}$$

where ***z*** is the remaining amount of Einstein's gravitational redshift after subtracting the Doppler blue shift, due to the motion of the gamma-ray source; and ***v''*** is the equivalent uniform velocity.

It has to be concluded, therefore, that, in spite of the fact that the amount of Einstein's gravitational redshift, due to the effect of Earth's gravitational field on the rising gamma rays, is greater than the amount of the Doppler blue shift, due to the motion of the gamma-ray source, by an incredibly minute amount equal to ***z***:

$$z = 1.060504861497 \times 10^{-25}$$

the calculated prediction, on the basis of the assumption of constant speed, according to which the speed of light is independent of the speed of the light source, along with Einstein's principle of equivalence, is consistent with the reported result of the Pound-Rebka Experiment.

B. In the Case of Falling Electromagnetic Radiation:

Let ***h*** stand for the height of the elevator in outer space.

& let ***a*** stand for the acceleration of the same elevator due to a mechanical force.

If a light source, placed on the ceiling, and receding with a speed, ***v***, from a detector, at rest on the floor of Einstein's elevator, emits its light towards the floor of the same mechanically accelerating elevator, then the total travel time of light, emitted at the start of the rest wave period, ***T***, can be computed through the use of the following equation:

$$t_1 = \frac{h - \frac{1}{2}at_1^2}{c} = \frac{\sqrt{c^2 + 2ah} - c}{a}$$

where t_1 is the total travel time of light, emitted, by a moving light source, at the start of the rest wave period, ***T***, and traveling with the speed, ***c***, from the ceiling to the floor of Einstein's elevator.

And likewise, the total travel time of light, emitted, by the same moving light source, at the end of the rest wave period, ***T***, can be obtained by the means of the following equation:

$$t_2 = \frac{h + vT - \frac{1}{2}aT^2 - aTt_2 - \frac{1}{2}at_2^2}{a} = \frac{\sqrt{c^2 + 2ah + 2aT\left(c+v\right)} - \left(c + aT\right)}{a}$$

where t_2 is the total travel time of light, emitted, by a moving light source, at the end of the rest wave period, ***T***, and traveling with the speed, ***c***, from the ceiling to the floor of Einstein's elevator; and the displacement, $0.5aT^2$, is made by the accelerating detector along with the floor of the mechanically accelerating elevator, during the same rest wave period of emitted light, ***T***.

And it follows, therefore, that the new wave period, ***T'***, can be computed by using this equation:

$$T' = T + \left(t_2 - t_1\right) = \frac{\sqrt{c^2 + 2ah + 2aT\left(c+v\right)} - \sqrt{c^2 + 2ah}}{a}$$

where ***T'*** is the shifted wave period, for light, emitted by a receding light source, towards the floor of Einstein's elevator.

And as a result, during the travel time of light, from the ceiling to the floor, Einstein's elevator will gain an mount of uniform speed, ***v'***, relative to the emitted light:

$$v' = aT' = \sqrt{c^2 + 2ah + 2aT\left(c+v\right)} - \sqrt{c^2 + 2ah}$$

where ***a*** is the mechanical acceleration.

And correspondingly, the frequency of received light, ***f'***, is given by this equation:

$$f' = \frac{1}{T'} = \frac{a}{\sqrt{c^2 + 2ah + 2aT\left(c+v\right)} - \sqrt{c^2 + 2ah}}$$

where ***v*** is the speed of the receding light source.

And therefore, the combined value of the Doppler red shift, due to the motion of the light source, and the Doppler blue shift, due to mechanical acceleration, for light traveling from the ceiling to the floor of Einstein's elevator, as predicted, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source, is equal to ***z***:

$$z = \frac{f' - f}{f} = \frac{a/f}{\sqrt{c^2 + 2ah + 2aT(c+v)} - \sqrt{c^2 + 2ah}} - 1$$

where ***f*** is the rest frequency of emitted light; and ***f'*** is the shifted frequency of received light.

And so, it follows, at once, that, by applying Einstein's principle of equivalence between mechanical acceleration and gravitational acceleration, to the stationary elevator, on Earth's surface, we can obtain the following formula, for calculating the combined value of the Doppler red shift, due to the motion of the light source, and Einstein's gravitational blue shift, for light traveling from the ceiling to the floor, under the sway of the force of gravity:

$$z = \frac{f' - f}{f} = \frac{g/f}{\sqrt{c^2 + 2gh + 2gT(c+v)} - \sqrt{c^2 + 2gh}} - 1$$

where ***z*** is the combined value of Einstein's gravitational blue shift, due to the effect of the force of gravity, and the Doppler red shift, due to the motion of the light source; ***g*** is the gravitational acceleration; and ***T*** is the rest wave period of emitted light.

And so, now, it's possible, based on the assumption of constant speed of light along with Einstein's principle of equivalence, to obtain the combined numerical value of Einstein's gravitational blue shift, due to the effect of Earth's gravitational field on the falling gamma rays, and the Doppler red shift, produced by the motion of the gamma-ray source relative to Einstein's stationary elevator and relative to Earth's gravitational field, and the equivalent uniform velocity, by inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a & Ref. #2***], into the above mathematical formula, for calculating the combined Doppler effect due to the motion of the gamma-ray source and and due to Earth's gravitational field, at the same time:

$$c = 299792458 \ \text{ms}^{-1}$$
$$g = 9.80665 \ \text{ms}^{-2}$$
$$h = 22.5 \ \text{m}$$
$$f = 3.46 \times 10^{18} \ \text{Hz}$$
$$v = 7.36 \times 10^{-7} \ \text{ms}^{-1}$$

And of course, once again, it should be noted that, in order to avoid the rounding errors of floating points and the problem of catastrophic cancellations, in quadratic formulas [***Ref. #5***], it's imperative, within the present context, to use a high precision calculator, in the computation of the extremely minute numerical values, in connection with the experiment under discussion.

The following numerical results are obtained, through the use of the desktop calculator, ***SpeedCrunch 0.12*** (Portable Edition), with its precision set to ***50*** digits:

$$z = 4.6969092386 \times 10^{-27}$$
$$v'' = -1.4080979656 \times 10^{-18} \ \text{ms}^{-1}$$

where ***z*** is the remaining amount of Einstein's gravitational blue shift of the falling gamma rays, upon the subtraction of the Doppler red shift, caused by the motion of the gamma-ray source; and ***v''*** is the equivalent uniform velocity.

And accordingly, we conclude, that, although the amount of the Doppler red shift, due to the motion of the gamma-ray source, is less than the amount of Einstein's gravitational blue shift, due to the effect of Earth's gravitational field on the falling gamma rays, by an extremely small amount equal to ***z***:

$$z = 4.6969092386 \times 10^{-27}$$

the computed prediction, on the basis of the assumption of constant speed of light, in accordance with which the speed of light is independent of the speed of the light source, along with Einstein's principle of equivalence, is consistent with the published result of the Pound-Rebka Experiment.

6. The Experimental Result on the Assumption of Ballistic Speed of Light:

As demonstrated earlier, in the present investigation, on the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent upon the speed of the light source, the rest wave periods and the rest frequencies of electromagnetic radiation, in the case of rising, as well as, in the case of falling electromagnetic radiation, under the effect of the force of gravity, remain unchanged and the same, as long as the light source and the Doppler-shift detector continue to be at rest relative to each other and relative to the gravitational field.

However, in the Pound-Rebka Experiment, the gamma-ray source is moving, in the opposite direction to that of the gravitational acceleration, ***g***, with a varying speed, ***v***, which has an optimal value that can be determined, beforehand, by inserting the values of ***g*** & ***h*** into the following equation:

$$v \approx \frac{gh}{c} = 7.36\times10^{-7} \ \ \mathrm{ms^{-1}}$$

where ***g*** is the gravitational acceleration; and ***h*** is the vertical distance between the gamma-ray source and the gamma-ray absorber.

And therefore, it's required, within the current context, to derive the relevant mathematical formulas, for computing the combined Doppler shift, due to the effect of the motion of the light source, and the effect of gravitational acceleration, on the same moving light source, during the time of emission, in the case of rising electromagnetic radiation, as well as, in the case of falling electromagnetic radiation, respectively, in accordance with the assumption of ballistic speed of light, on the basis of which the speed of light is dependent of the speed of the light source.

A. In the Case of Rising Electromagnetic Radiation:

Let ***h*** stand for the height of the stationary elevator on Earth's surface .

And let ***g*** stand for the gravitational acceleration.

If a light source, moving with a speed, ***v***, from the floor towards the ceiling of the stationary elevator, emits its light towards a Doppler-shift detector, placed at rest on the ceiling of the same elevator, then the total travel time of light, emitted at the start of the rest wave period, ***T***, can be computed, on the basis of the assumption of ballistic speed of light, through the use of the following equation:

$$t_1 = \frac{h + \frac{1}{2} g t_1^2}{c + v} = \frac{(c+v) - \sqrt{(c+v)^2 - 2gh}}{g}$$

where t_1 is the total travel time of light, emitted at the start of the rest wave period, ***T***, and traveling at the velocity resultant, ***(c + v)***, from the floor to the ceiling of a stationary elevator on Earth's surface.

And in the same way, the total travel time of light, emitted at the end of the same rest wave period, ***T***, and traveling at the velocity resultant, ***(c + v - gT)***, from the floor to the ceiling of of the same stationary elevator can be obtained by using the following equation:

$$t_2 = \frac{h - vT + \frac{1}{2} g T^2 + \frac{1}{2} g t_2^2}{c + v - gT} = \frac{(c + v - gT) - \sqrt{(c+v)^2 - 2gh - 2gcT}}{g}$$

where t_2 is the travel time of light, emitted at the end of the rest wave period, ***T***, and traveling with the velocity resultant (***c + v - gT***) from the floor to the ceiling of the stationary elevator.

And, accordingly, it follows, at once, that the new wave period, ***T'***, can be computed through the use of the following equation:

$$T' = T + (t_2 - t_1) = \frac{\sqrt{(c+v)^2 - 2gh} - \sqrt{(c+v)^2 - 2gh - 2gcT}}{g}$$

where ***T'*** is the shifted wave period, for light, emitted by a moving light source, and traveling from the floor towards the ceiling of the stationary elevator.

And subsequently, during its time of flight, from the floor to the ceiling of the stationary elevator, the emitted light loses an amount of uniform speed equals to ***v'***, relative to the same stationary elevator:

$$v' = gT' = \sqrt{(c+v)^2 - 2gh} - \sqrt{(c+v)^2 - 2gh - 2gcT}$$

where ***g*** is the gravitational acceleration on Earth's surface; and T' is the shifted wave period of received light.

And correspondingly, the frequency of received light, ***f'***, is given by this equation:

$$f' = \frac{1}{T'} = \frac{g}{\sqrt{(c+v)^2 - 2gh} - \sqrt{(c+v)^2 - 2gh - 2gcT}}$$

where ***v*** is the speed of the light source with respect to Earth's gravitational field.

And therefore, the combined Doppler-shift value of the Doppler blue shift, due to the motion of the light source, and the Doppler red shift, due to the effect of Earth's gravitational acceleration, on the moving light source, during the time of emission, in the case, in which the rising light is traveling from the floor to the ceiling of the stationary elevator, as predicted, on the basis of the assumption of ballistic speed of light, is equal to ***z***:

$$z = \frac{f - f'}{f} = 1 - \frac{g/f}{\sqrt{(c+v)^2 - 2gh} - \sqrt{(c+v)^2 - 2gh - 2gcT}}$$

where ***f*** is the rest frequency of emitted light; and ***f'*** is the shifted frequency of received light.

And so, now, it's, quite, easy to obtain the numerical value of the combined Doppler shift of both the Doppler blue shift, due to the motion of the light source, and the Doppler red shift, produced by the speed difference, ***gT***, due to the effect of Earth's gravitational acceleration, on the moving light source, during the time of emission, in the case of light, traveling from the floor to the ceiling of the stationary elevator, and the equivalent uniform velocity, by, simply, inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a*** **&** ***Ref. #2***], into the above equation:

$$c = 299792458 \ \text{ms}^{-1}$$
$$g = 9.80665 \ \text{ms}^{-2}$$
$$h = 22.5 \ \text{m}$$
$$f = 3.46 \times 10^{18} \ \text{Hz}$$
$$v = 7.36 \times 10^{-7} \ \text{ms}^{-1}$$

However, in order to do away with the well-known rounding errors of floating points and the notorious catastrophic cancellations, in quadratic formulas [***Ref. #5***], a high precision calculator should be used, within the present context, in obtaining the numerical results of these calculations.

The two numerical results, below, are obtained, through the use of the desktop calculator, ***SpeedCrunch 0.12*** (Portable Edition), with its precision set to ***50*** digits:

$$z = 1.060504861497 \times 10^{-25}$$
$$v'' = +3.179313591 \times 10^{-17} \text{ ms}^{-1}$$

where z is the remaining amount of the Doppler red shift, due to the speed difference, ***gT***, after subtracting the Doppler blue shift, caused by the motion of the gamma-ray source, during the time of emission; and v'' is the equivalent uniform velocity.

It has to be concluded, therefore, that, although the amount of the Doppler blue shift, due to the motion of the gamma-ray source, is less than the amount of the Doppler red shift, generated by the speed difference, ***gT***, due to the effect of Earth's gravitational field on the moving source of the rising gamma rays, during the time of emission, by an extremely small amount equal to z:

$$z = 1.060504861497 \times 10^{-25}$$

the calculated prediction, on the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent upon the speed of the light source, is consistent with the reported result of the Pound-Rebka Experiment.

B. In the Case of Falling Electromagnetic Radiation:

Let h denote the height of an elevator at rest on Earth's surface.

And let g denote the gravitational acceleration.

If a light source, located on the ceiling, and receding with a speed, v, from the floor of the stationary elevator, emits its light towards a Doppler-shift detector, at rest on the floor of the same elevator, then the total travel time of light, emitted at the start of the rest wave period, T, can be obtained by the means of the following equation:

$$t_1 = \frac{h - \frac{1}{2} g t_1^2}{c - v} = \frac{\sqrt{(c-v)^2 + 2gh} - (c-v)}{g}$$

where t_1 is the total travel time of light, emitted at the start of the rest wave period, T, and traveling with the velocity resultant, $(c - v)$, from the ceiling to the floor of the stationary elevator.

And in the same manner, the total travel time of light, emitted at the end of the same rest wave period, ***T***, and traveling with the velocity resultant, (***c – v + gT***), from the ceiling to the floor of the same stationary elevator. can be calculated through the use of the following equation:

$$t_2 = \frac{h + vT - \frac{1}{2}gT^2 - \frac{1}{2}gt_2^2}{c - v + gT} = \frac{\sqrt{(c-v)^2 + 2gh + 2gcT} - (c - v + gT)}{g}$$

where t_2 is the travel time of light, emitted at the end of the rest wave period, ***T***, and traveling with the velocity resultant, (***c – v + gT***), from the ceiling to the floor of the stationary elevator.

And it follows, therefore, that the new wave period, ***T′***, can be computed by using this equation:

$$T' = T + (t_2 - t_1) = \frac{\sqrt{(c-v)^2 + 2gh + 2gcT} - \sqrt{(c-v)^2 + 2gh}}{g}$$

where ***T′*** is the shifted wave period of light, emitted by a receding light source, towards a detector at rest on the floor of the stationary elevator.

And correspondingly, during its travel time from the ceiling to the floor of the stationary elevator, the emitted light must gain an amount of uniform speed, ***v′***, relative to the same stationary elevator:

$$v' = gT' = \sqrt{(c-v)^2 + 2gh + 2gcT} - \sqrt{(c-v)^2 + 2gh}$$

where ***g*** is the gravitational acceleration on Earth's surface.

And therefore, the shifted frequency of received light, ***f′***, is obtained by the use of this equation:

$$f' = \frac{1}{T'} = \frac{g}{\sqrt{(c-v)^2 + 2gh + 2gcT} - \sqrt{(c-v)^2 + 2gh}}$$

where ***v*** is the speed of the light source.

And consequently, the combined value of the Doppler red shift, due to the motion of the light source, and the Doppler blue shift, due to the speed difference, ***gT***, caused by the effect of Earth's gravitational acceleration, on the moving light source, during the time of emission, in the case, in which the falling electromagnetic radiation is traveling from the ceiling to the floor of the stationary elevator, as predicted, on the basis of the assumption of ballistic speed of light, is equal to ***z***:

$$z = \frac{f' - f}{f} = \frac{g/f}{\sqrt{(c-v)^2 + 2gh + 2gcT} - \sqrt{(c-v)^2 + 2gh}} - 1$$

where ***f*** is the rest frequency of emitted light; and ***f'*** is the shifted frequency of received light.

And so, let's, now, calculate the combined value of the Doppler red shift, due to the motion of the light source, and the Doppler blue shift, due to the speed difference, ***gT***, generated by the effect of Earth's gravitational field, on the moving light source, during the time of emission, in the case of light, traveling from the ceiling to the floor of the stationary elevator on Earth's surface, and the equivalent uniform velocity, by inserting the following numerical data, from the Pound-Rebka Experiment [***Ref. #1.a*** **&** ***Ref. #2***], into the above equation:

$$c = 299792458 \ \text{ms}^{-1}$$
$$g = 9.80665 \ \text{ms}^{-2}$$
$$h = 22.5 \ \text{m}$$
$$f = 3.46 \times 10^{18} \ \text{Hz}$$
$$v = 7.36 \times 10^{-7} \ \text{ms}^{-1}$$

And, once again, in order to avoid the rounding errors of floating points and the catastrophic cancellations, in quadratic formulas [***Ref. #5***], it's necessary to use a high precision calculator, in the current calculations.

The following numerical results are obtained, through the use of the desktop calculator, ***SpeedCrunch 0.12*** (Portable Edition), with its precision set to ***50*** digits:

$$z = 1.80214311126258 \times 10^{-25}$$
$$v'' = -5.4026891299 \times 10^{-17} \ \text{ms}^{-1}$$

where ***z*** is the remaining amount of the Doppler blue shift, due to the speed difference, ***gT***, after subtracting the Doppler red shift, due to the motion of the gamma-ray source; and ***v''*** is the equivalent uniform velocity.

We conclude, therefore, that, although the amount of the Doppler red shift, due to the motion of the gamma-ray source, is less than the amount of the Doppler blue shift, due to the speed difference, ***gT***, caused by the effect of Earth's gravitational field on the moving source of the falling rising gamma rays, during the time of emission, by an incredibly minute amount equal to ***z***:,

$$z = 1.80214311126258 \times 10^{-25}$$

the calculated prediction, on the basis of the assumption of ballistic speed of light, in accordance with which the speed of light is dependent upon the speed of the light source, is consistent with the published result of the Pound-Rebka Experiment.

7. Concluding Remarks:

As demonstrated above, in the case, in which the gamma-ray source is moving in the opposite direction to that of Earth's gravitational field, the assumption of constant speed of light and the assumption of ballistic speed of light give the same numerical value, for the Doppler shift of rising and falling gamma rays, under the effect of Earth's gravitational field, as measured in the Pound-Rebka Experiment.

And for that reason, the experimental result, reported by R. V. Pound and G. A. Rebka, is inconclusive, in this regard.

In other words, although it shows, for certain, that the rest wave periods and the rest frequencies of rising and falling gamma rays, in the gravitational field of the earth, have been shifted, by the Doppler effect, due to the force of gravity, the Pound-Rebka Experiment cannot, in the case, in question, determine, with any degree of certainty, whether the Doppler shift, under investigation, is the predicted gravitational redshift, caused by the effect of the force of gravity on the emitted gamma rays, as computed on the basis of the assumption of constant speed of light and Einstein's principle of equivalence; or it's, instead, the predicted Doppler shift, caused by the speed difference, ***gT***, due to the effect of the force of gravity on the moving gamma-ray source, itself, during the time of emission, as calculated in accordance with the assumption of ballistic speed of light.

However, in the case, in which the gamma-ray source is at rest relative to the gamma-ray absorber and Earth's gravitational field, no Doppler shift of the rest wave periods and the rest frequencies of rising and falling gamma rays, is predicted on the basis of the assumption of ballistic speed of light.

And therefore, it's possible, in principle, for the Pound-Rebka Experiment, in the case, in which the gamma-ray source and the gamma-ray absorber are stationary with respect to each other, to rule out, decisively, one of the two aforementioned predictions.

It's, by no means, clear whether, or not, R. V. Pound and G. A. Rebka could have chosen the experimental setup, in which the gamma ray source is at rest relative the gamma-ray absorber and relative to Earth's gravitational field, for their experiment; but, very likely, they would have tried, very hard, to do so, if they were informed, somehow, beforehand, that the calculations, on the basis of the assumption of ballistic speed of light, render their experimental evidence for Einstein's gravitational redshift, entirely, inconclusive.

In any case, there has been no mention of any conclusive experimental evidence, in the surveyed literature, so far, for ruling in or ruling out either one of the two theoretical predictions, under discussion.

And so, the important question, now, is this:

Which of those two theoretical predictions, discussed above, will, most likely, be, experimentally, ruled out, someday, in the near or in the far the future?

The answer depends on whom you ask, of course; but, on the face of it, Einstein's gravitational redshift seems, very much, to have been built upon shaky theoretical foundations, to start with; and hence, it's more likely than not, to be ruled out, by experimental means, sometime, in the future.

In particular, Einstein's principle of equivalence, upon which the predicted gravitational redshift is based, appears arbitrary and, theoretically, unjustified.

It's, certainly, true that mechanical acceleration and gravitational acceleration can be shown to be equivalent to each other, in all cases of ballistic light, particles, and projectiles, in general.

But the main problem, here, for the prediction of gravitational redshift, is that, although calculations, based on the assumption of constant speed of light, in the case of mechanical acceleration, give numerical values of Doppler shift equal to the predicted numerical values of Einstein's gravitational redshift, there is, absolutely, no realistic way, for gravitational acceleration, in the case of stationary light sources and stationary detectors, to have any effect, at all, on the rest wave periods and the rest frequencies of electromagnetic radiation.

In any case, it is not possible, from a theoretical standpoint, to be demonstrated, on the basis of the assumption of constant speed of light, that a frame of reference accelerating with respect to electromagnetic radiation, is equivalent to electromagnetic radiation accelerating with respect to a stationary or uniformly moving frame of reference.

In a nutshell, an elevator accelerating relative to a light beam is equivalent to a light beam accelerating relative to a stationary elevator, if and, only, if the assumption of ballistic speed of light is true.

There are, also, some clear indications that the inclusion of Einstein's gravitational redshift within the Doppler-data-reduction procedures, in deep space navigation, leads, sometimes, to overestimating the true speed, when the spacecraft is at a higher gravitational potential and the earth at a lower gravitational potential, as in the case of Pioneer ***10*** & Pioneer ***11*** ***[Ref. #16a & Ref. #17]***, and at some other times, it leads to underestimating the true speed, when the earth is at a higher gravitational potential and the spacecraft, under observation, is at a lower gravitational potential, as in the case of Galileo ***I*** & Galileo ***II*** ***[Ref. #16b & Ref. #18]***.

Now, with regard to the Pound-Rebka Experiment, there is a potential problem that has to be looked at, closely, analyzed, further, and examined in detail,.

Does the tangential velocity of Earth, around its geometrical axis, have any measurable effect, on the reported result of the Pound-Rebka Experiment?

The Jefferson Physical Laboratory, at which R. V. Pound and G. A. Rebka carried out their experiment, is located at the geographical latitude, ***42.3770°*** N.

And, consequently, the tangential velocity of the earth, there, is equal to v_E:

$$v_E = 460 \times \cos\left(42.3770\right) = 339.8139 \text{ ms}^{-1}$$

where Earth's tangential velocity, at the equator, is equal to ***460*** meters per second.

On the basis of the assumption of constant speed of light, the above tangential velocity, due to Earth's rotation, is equivalent to the movement of a mechanically accelerating elevator at right angles to the vector of its acceleration.

And therefore, it follows, necessarily, that, during the travel time of rising gamma rays, t, the elevator will move, transversely, a distance equal to d:

$$d = tv_E$$

where t is calculated by using this equation:

$$t = \frac{c - \sqrt{c^2 - 2gh}}{g}$$

where g & h have the same values as in the Pound-Rebka Experiment; i.e.,

$$g = 9.80665 \text{ ms}^{-2}$$
$$h = 22.5 \text{ meters}$$
$$c = 299792458 \text{ ms}^{-1}$$

And therefore, the rising gamma rays, in the Pound-Rebka Experiment, will drift backward with respect to the vector of Earth's tangential velocity, a distance equal to this numerical value:

$$d = 2.55 \times 10^{-5} \ \text{m}$$

However, since the cross section of the rising gamma-ray beam, through the helium bag, is much greater than ***0.0255*** of a millimeter, the tangential velocity of Earth's rotation can't, possibly, make the rising gamma rays, in the Pound-Rebka Experiment, miss, altogether, the transversely moving gamma-ray absorber, as computed in accordance with the assumption of constant speed of light and Einstein's principle of equivalence. And the same, of course, applies to the falling gamma rays, as well.

As for the effect of the tangential velocity of the Jefferson Physical Laboratory's tower, due to Earth's rotation, on the rising and falling gamma rays, in the Pound-Rebka Experiment, as calculated on the basis of the assumption of ballistic speed of light, it can be illustrated by starting with this equation:

$$c' = \sqrt{(c \pm v)^2 + v_E^2}$$

where c' is the velocity resultant of rising and falling gamma rays; v is the velocity of the gamma-ray source; and v_E is the tangential velocity, due to the rotation of the earth.

And accordingly, the initial direction of rising gamma rays, as well as that of falling gamma rays, is tilted, towards the forward direction of Earth's tangential velocity, from the vertical, by a very small amount equal to the angle, β:

$$\beta = \arctan\left(\frac{v_E}{c \pm v}\right)$$

where c is the muzzle speed of light.

And it should be noted, within the current context, that, in the Pound-Rebka Experiment, the values of the angle, β, increase with the decreasing speed of rising gamma rays, from its initial value, at the gamma-ray source:

$$\beta = \arctan\left(\frac{v_E}{c + v}\right)$$

where v is the speed of the gamma-ray source relative to the gamma-ray absorber;

to its final value, at the gamma-ray absorber:

$$\beta = \arctan\left(\frac{v_E}{c}\right)$$

where v_E is the tangential velocity, due to the rotation of the earth.

While, by contrast, the values of the angle, β, decrease with the increasing speed of falling gamma rays, from its initial value, at the gamma-ray source:

$$\beta = \arctan\left(\frac{v_E}{c - v}\right)$$

to its final value, at the gamma-ray absorber:

$$\beta = \arctan\left(\frac{v_E}{c}\right)$$

where c is the muzzle speed of light.

Nonetheless, because, according to the assumption of ballistic speed of light, the final value of the angle, β, and the angle of light aberration balance each other out, the direction of incidence, with respect to the gamma-ray absorber, remains equal to 90^o, in the case of rising gamma rays, as well as, in the case of falling gamma rays, respectively.

And, now, finally, with regard to the calculated predictions, on the basis of the assumption of ballistic speed of light, according to which the speed of light is dependent upon the speed of the light source, the following essential aspects, in the case of gravitational acceleration, as well as, in the case of mechanical acceleration, should be pointed out, explicitly, and made clear:

1. In the case of gravitational acceleration, the predicted effects, on electromagnetic radiation from moving sources, as computed in accordance with the assumption of ballistic speed of light, occur, continually, inside the gravitational field, in question, and outside of it, as well.

2. In the case of mechanical acceleration, the predicted effects, as calculated in accordance with the assumption of ballistic speed of light, occur, continually, inside the accelerating frame of reference, in question, and outside of it, as well.

3. In the case of gravitational acceleration, the motion of the light source, with respect to the gravitational field, is a necessary condition and a basic requirement for the calculations of the predicted shifts, in the wave periods as well as in the frequencies of received light, on the basis of the assumption of ballistic speed of light.

4. Calculations, based on the assumption of ballistic speed of light, predict that the effect of mechanical acceleration, on rising electromagnetic radiation, continues to occur, indefinitely,

according to this equation, inside and outside the accelerating frame of reference:

$$\lambda' = cT - aT(t - T)$$

where T is the rest wave period; a is the mechanical acceleration; c is the muzzle speed of light; λ' is the shifted wavelength; and t is the elapsed time since emission.

The Doppler blue shift, predicted by the above formula, can be observed and measured, from every frame of reference, except from inside the mechanically accelerating frame of reference, in which the Doppler blue shift, due to the speed difference, aT, is canceled out by the Doppler red shift, due to the uniform velocity gained, during the light travel time, t, by the accelerating frame of reference.

5. Moreover, the Doppler blue shift, as predicted by this formula:

$$\lambda' = cT - aT(t - T)$$

increases, in direct proportion to the amount of elapsed time since emission, until the light, emitted at the end of the wave period, T, and traveling with the speed $(c + aT)$ overtakes the light, emitted at the start of the same wave period, T, and traveling with the speed (c), after an elapsed interval of time, since emission, equal to t_{max}:

$$t_{\max} = \frac{c}{a} + T$$

where a is the mechanical acceleration.

After reaching its maximum amount, at the elapsed interval of time, t_{max}, since emission, the Doppler blue shift, as predicted by the above formula, starts to decrease, in inverse proportion to the amount of elapsed time, $(t - t_{max})$, since emission, until it reaches its minimum value, and the value of the rest frequency, f, as well as the value of the rest wave period, T, are restored, after an elapsed interval of time equal to t_{min}:

$$t_{\min} = t - t_{\max} = \frac{c}{a} + T$$

where c is the muzzle speed of light; and T is the rest wave period of emitted light.

Immediately, after the elapsed interval, t_{min}; i.e., after a total amount of time, elapsed since emission equal to t:

$$t = 2\left(\frac{c}{a} + T\right)$$

the aforementioned formula predicts, in all cases, Doppler red shifts, whose amounts increase, indefinitely, in direct proportion to the amount of elapsed time since the elapse of the interval of time, t_{min}.

6. Likewise, calculations, based on the assumption of ballistic speed of light, predict that the effect of mechanical acceleration, on falling electromagnetic radiation, continues to occur, according to this equation, inside and outside the accelerating frame of reference:

$$\lambda' = cT + aT\left(t - T\right)$$

where T is the rest wave period; a is the mechanical acceleration; c is the muzzle speed of light; λ' is the shifted wavelength; and t is the elapsed time since emission.

The Doppler red shift, predicted by the above formula, can be observed and measured, from every frame of reference, except with respect to the mechanically accelerating frame of reference, in which the Doppler red shift, due to the speed difference, aT, is balanced out by the Doppler blue shift, due to the uniform velocity gained, during the light travel time, t, by the accelerating frame of reference.

7. In addition to being observable, from every frame of reference, except from inside the mechanically accelerating frame of reference, itself, the amount of the predicted Doppler red shift, z, due to mechanical acceleration, increases in direct proportion to the increase in the interval of time since emission, t; and hence, the amount of the Doppler red shift, z, is, necessarily, proportional to the displacement, d, made by the emitted light, since emission; i.e.,

$$z = \frac{a\left(t - T\right)}{c} = \frac{a\left(d - cT\right)}{c^2}$$

where a is the mechanical acceleration; while d is obtained from this relation:

$$d = ct$$

where c is the muzzle speed of light.

8. Calculations, based on the assumption of ballistic speed of light, predict that the Doppler blue shift, due to the speed difference, gT, caused by the effect of gravitational acceleration, on the moving source of falling electromagnetic radiation, during the time of emission, continues to occur, according to this equation, inside and outside the gravitational field:

$$\lambda' = cT - gT\left(t - T\right)$$

where T is the rest wave period; g is the gravitational acceleration; c is the muzzle speed of light; λ' is the shifted wavelength; and t is the elapsed time since emission.

The Doppler blue shift, predicted by the above formula, can be observed and measured, from every frame of reference, including the reference frame of the gravitational field, in question.

9. Furthermore, the Doppler blue shift, as predicted by the following formula:

$$\lambda' = cT - gT\left(t - T\right)$$

increases, in direct proportion to the amount of elapsed time since emission, until the light, emitted at the end of the rest wave period, T, and traveling with the speed $(c + gT)$ overtakes the light, emitted at the start of the same rest wave period, T, and traveling with the speed (c), after an elapsed interval of time, since emission, equal to t_{max}:

$$t_{\max} = \frac{c}{g} + T$$

where g is the gravitational acceleration.

After reaching its maximum amount, at the elapsed interval of time, t_{max}, since emission, the Doppler blue shift, as predicted by the above formula, decreases, in inverse proportion to the amount of elapsed time, $(t - t_{max})$, since emission, until it reaches its minimum value, and the rest wave period, T, and the rest frequency, f, are restored, after an elapsed interval of time equal to t_{min}:

$$t_{\min} = t - t_{\max} = \frac{c}{g} + T$$

where c is the muzzle speed of light.

Immediately, after the elapsed interval, t_{min} — i.e., after a total amount of time, elapsed since emission equal to t:

$$t = 2\left(\frac{c}{g} + T\right)$$

the aforementioned formula predicts, in all cases, Doppler red shifts, whose amounts increase, indefinitely, in direct proportion to the amount of elapsed time since the elapse of the interval of time, t_{min} , as defined above.

10. Calculations, based on the assumption of ballistic speed of light, predict that the Doppler red shift due to the speed difference, ***gT***, produced by the effect of the gravitational field, on the moving source of rising electromagnetic radiation, during the time of emission, will continue to occur, endlessly, according to this equation, inside and outside of the same gravitational field:

$$\lambda' = cT + gT\left(t - T\right)$$

where ***T*** is the rest wave period; ***g*** is the gravitational acceleration; ***c*** is the muzzle speed of light; ***λ'*** is the shifted wavelength; and ***t*** is the elapsed time since emission.

The Doppler red shift, predicted by the above formula, can be observed and measured, from every frame of reference, including the reference frame of the gravitational field, in question.

11. In addition to being observable, from every frame of reference, the predicted Doppler red shift, ***z***, caused by the speed difference, ***gT***, due to the effect of the force of the gravity on the moving light source, during the time of emission, increases, in direct proportion to the increase in the interval of time since emission, ***t***; and hence, the amount of the Doppler red shift, ***z***, is, directly, proportional to the displacement, ***d***, made by the emitted light, since emission; i.e.,

$$z = \frac{g\left(t - T\right)}{c} = \frac{g\left(d - cT\right)}{c^2}$$

where ***g*** is the gravitational acceleration; and ***d*** is obtained in accordance with this relation:

$$d = ct$$

where ***c*** is the muzzle speed of light.

12. With the Sun's sphere of influence, for instance, the gravitational blue shift, due to the effect of the gravitational field of the Sun, on the propagation of light, as computed on the basis of the assumption of constant speed of light and Einstein's principle of equivalence, is, always, greater, by a very small amount, than the Doppler blue shift, due to the speed difference, ***gT***, as computed in accordance with the assumption of ballistic speed of light. That is because the former is proportional to the strength of the gravitational field, along the path of

electromagnetic radiation; while the latter is proportional to the strength of the gravitational field, along the path of the electromagnetic-radiation source at the time of emission.

13. And furthermore, within the Sun's sphere of influence, the Doppler red shift, as computed in accordance with the assumption of ballistic speed of light is, always, greater, by a very small amount, than the gravitational redshift, as computed on the basis of the assumption of constant speed of light and Einstein's principle of equivalence, And that is, also, because the former is proportional to the strength of the gravitational field, along the path of the electromagnetic-radiation source at the time of emission; while the latter is proportional to the strength of the gravitational field, along the path of electromagnetic radiation, itself.

14. Because the values of the Doppler blue shift and the Doppler red shift, ***z***, as calculated on the basis of the assumption of ballistic speed of light, vary, in direct proportion, with the values of the acceleration resultant, $\boldsymbol{a_r}$, and with the values of the elapsed interval of time since emission, ***t***, as it can be deduced from this general formula:

$$z = \frac{a_r\left(t-T\right)}{c}$$

they have the potential of altering stellar spectra, significantly, on the galactic scale, as well as, on the cosmological scale.

15. More importantly, the fact that the values of the Doppler red shift, ***z***, in the case of mechanical acceleration, as calculated by using this equation:

$$z = \frac{a\left(t-T\right)}{c} = \frac{a\left(d-cT\right)}{c^2}$$

and the value of the Doppler red shift, ***z***, in the case of gravitational acceleration, as calculated by using this equation:

$$z = \frac{g\left(t-T\right)}{c} = \frac{g\left(d-cT\right)}{c^2}$$

both are, directly, proportional to the distance between the light source, at the time of emission, and the Doppler-shift detector, at the time of reception, shows, very clearly, that it's possible, from a theoretical perspective, to account, in a straightforward manner, for Edwin Hubble's Empirical '*Relation between Distance and Radial Velocity among Extra-Galactic Nebulae*' [***Ref. #13***], on the basis of the assumption of ballistic speed of light, alone and by itself, and without resorting to any helper hypotheses or to any of the far-fetched hypotheses such as expanding universe, steady state, tired light, ...etc..

And in conclusion, therefore, the published result of the Pound-Rebka Experiment is inconclusive with regard to testing and verifying the theoretical prediction of Einstein's gravitational redshift, as calculated and worked out on the basis of Einstein's principle of equivalence and the assumption of constant speed of light, in accordance with to which the speed of light is independent of the speed of the light source.

And that is because, more than anything else, the motion of the gamma-ray source, in the aforementioned experiment, with respect to the gamma-ray absorber and the gravitational field of the earth, makes it possible, as demonstrated in the current investigation, to calculate, predict, and interpret, in a distinct and satisfactory manner, the Pound-Rebka experimental result, in accordance with the assumption of ballistic speed of light, on the basis of which the speed of light is dependent upon the speed of the light source.

And, it should be clear, accordingly, that the Pound-Rebka Experiment and other similar experiments, with moving sources of electromagnetic radiation can, conclusively, confirm or disconfirm neither of the two theoretical predictions, investigated and analyzed in detail above, except in the case, in which the light source and the Doppler-shift detector are at rest with respect to each other and with respect to the gravitational field, the effects of which on the rest wave periods and the rest frequencies of electromagnetic radiation, have yet to be, experimentally, tested and verified.

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