Journal of Modern Physics, 2014, 5, 884-899
Published Online June 2014 in SciRes. http://www.scirp.org/journal/jmp
http://dx.doi.org/10.4236/jmp.2014.59092

Scientific Research

The Light as Composed of Longitudinal-Extended Elastic Particles Obeying to the Laws of Newtonian Mechanics

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Received 16 April 2014; revised 12 May 2014; accepted 7 June 2014

Abstract

It is shown that the speed of *longitudinal-extended elastic particles*, emitted during an emission time *T* by a source S at speed *u* (escape speed toward the infinity due to all the masses in space), is invariant for any Observer, under the Newtonian mechanics laws. It is also shown that a cosmological reason implies the light as composed of such *particles* moving at speed *u* (function of the total gravitational potential). Compliance of *c* with Newtonian mechanics is shown for Doppler effect, Harvard tower experiment, gravitational red shift and time dilation, highlighting, for each of these subjects, the differences versus the relativity.

Keywords

Escape Speed, Harvard Tower Experiment, Time Dilation, Redshift, Doppler Effect, Compton Effect

1. Introduction

Here we present a solution, in accordance to the Newtonian mechanics, to the *apparent* constancy of c, based on following assumptions:

1) Gravity fields fixed to their related masses (*intending that each field is moving together with its generating mass*).

2) Finite mass of the universe, *implying a finite value of* U (*total gravitational potential*) *and therefore of* u (*escape speed from the universe due to all the masses in space*).

3) Light composed of longitudinal-extended elastic particles (*as defined on* §4) moving at speed $c = u$. *This*

How to cite this paper: Bacchieri, A. (2014) The Light as Composed of Longitudinal-Extended Elastic Particles Obeying to the Laws of Newtonian Mechanics. *Journal of Modern Physics*, **5**, 884-899. http://dx.doi.org/10.4236/jmp.2014.59092

equality is supported by a cosmological reason, see §2.

On above bases (including, needless to say, Newton's absolute time and space) we find:

a) The relation between u (*total* escape speed) and U (*total* gravitational potential), giving to the speed of light the cosmological reason of its value.

b) On Earth, the variation of u, (and therefore of c as per assumption III), due to the variation of U (mainly caused by the variable distance Earth-Sun) is, *during one year*, Δu $(=\Delta c) \le \pm 0.05$ m·s^{-1}, hence within the accuracy of the measured value of c.

c) The invariance of the measure of c for any Reference frame under the Newtonian mechanics laws.

d) The longitudinal, generic and transverse Doppler effect for *longitudinal-extended elastic particles*, as defined, and their physical characterization.

e) As for the Harvard tower experiment [1]-[3], regarding the variation of frequency (or wavelength) between a source (of gamma rays) and an absorber at different height, our relations give a shift equal to the observed and also predicted by the Relativity. Anyhow, with the source on the base (of the tower) the light arriving to the top has, as for the GR, a lower frequency, whereas on our bases, is the length of our *particles* which decreases (together with c); on the contrary, with source on the top, GR predicts an increase of the frequency of the light arrived to the base, whereas we show that, during the same path (top-base), is the length of these *particles* which increases (together with c), giving a red shift. Moreover, as for the value of the compensating speed source-absorber, (necessary to restore their resonance), we point out that the experiment did not give *any clear indication* about the effective direction of this speed. Indeed, scope of that experiment was to "establish the validity of the predicted gravitational red shift" [2], hence the only value of this speed was taken in consideration; here, on §6, we show that, on our bases, the effective direction of this speed is contrary in both cases (source on top or base), to the one predicted (but not verified) by the Relativity.

f) As for the gravitational time dilation, on §6, it is shown that taking a source (of light) in altitude, it yields a negative variation of c as well as a negative variation of the frequency ν inducing atomic clocks to run faster; moreover, through our Equation (29) regarding a source circling (around the Earth), we obtain, see (46), the exact variation of the ticking time of GPS system.

g) As for high red shifts related to far sources, we show that, disregarding the relative motion Earth-source, they depend on the increase of c (as well as the increase of the length of the said "longitudinal-extended elastic particles") during the path of light toward higher (in absolute value) potential; on §7, **Table 1**, we give the values of c (on these far sources) related to the observed red shifts.

h) Our Equation (17), (regarding our Doppler effect for the light), applied to the Compton effect (*indubitable* Doppler effect), gives, see Appendix A, the Compton equation, *which cannot be obtained* through the relativistic Doppler effect equations.

2. Total Escape Speed (from a Point toward the Infinity) Due to All the Masses in Space

As known, considering in space one only mass M (regarded as a point-like), the gravitational potential U acting on a particle having mass $m \ll M$, assuming $U_\infty = 0$, with s the distance M-m, is $U = -MG/s$; this relation, according to our *first assumption* (I), is always valid in spite of any reciprocal motion between M and m. The related Conservation of Energy (CoE), $E = U + K$, (where $K = \frac{1}{2}u^2$ represents the unitary, *i.e.* for unit of mass, kinetic energy of our particle arriving from the infinity, where $u_\infty = 0$), for $E = 0$ gives $U = -K$, leading to

$$u = \sqrt{2K} = \sqrt{-2U} = \sqrt{2MG/s} \tag{1}$$

which is a scalar, (called *escape speed*), representing (in the considered point) the value of the velocity $\mathbf{u}$, any massive particle, under a potential U, needs to reach the infinity, so $\mathbf{u}$ (*escape velocity*)must be referred to M.

Considering now two masses M_1 and M_2, having, at a given time, distances s_1 and s_2 from a considered point (we may call it Emission point E_p), the potential $U_{1,2}$ in E_p becomes

$$U_{1,2} \equiv U_1 + U_2 = -(M_1G/s_1) - (M_2G/s_2) \tag{2}$$

Now, the escape speed from two masses can be written

$$u_{1,2} \equiv \sqrt{-2U_{1,2}} \equiv \sqrt{-2(U_1 + U_2)} = \sqrt{(2M_1G/s_1) + (2M_2G/s_2)} \tag{3}$$

which is the value, in the considered point E_p of the (escape) velocity $\mathbf{u}_{1,2}$ which has to be referred (at the considered time), to the point, we may call it Centre of potential (C_p), where $|U_{1,2}|$ has the max value. Then, as $\sqrt{2M_1G/s_1} = u_1$ and $\sqrt{2M_2G/s_2} = u_2$ we also get

$$u_{1,2}^2 = u_1^2 + u_2^2 \tag{4}$$

therefore the escape speed due to all the n masses in space becomes

$$u = \sqrt{\sum u_n^2} = \sqrt{-2U} = \sqrt{\sum 2M_nG/s_n} \tag{5}$$

with $\sum M_n \equiv M_u$ the universe mass, $U\left(= -\sum M_nG/s_n = -\frac{1}{2}u^2\right)$ the *total* gravitational potential in the considered point E_p, and where u (function of U in E_p) can be called as *total escape speed* (toward the infinity), while the escape velocity $\mathbf{u}$ is referred to the centre C_p. Indeed, any unitary massive particle during its path toward the infinity, has to comply with the CoE, $U + K = 0$, where $K = \frac{1}{2}u^2$ giving to this particle a speed u (which depends on the location of the source) and yielding, for all the masses, the total energy equal to zero [Compliance of light with above relation $E = U + K$, is shown on Appendix B].

We assume now the equality $c = u$, hereafter supported by the estimated mass of universe and also by a cosmological reason: in fact, if $c > u$ the energy of light will be lost forever and furthermore the *observable* masses, following the always increasing mass of light going toward the infinity, will also tend to the infinity moving away from each other. On the contrary, if $c < u$, all the masses in space (having speed lower than u), will tend to a gravitational collapse, whereas for $c = u$, the mass of light, tending to the infinity in an unlimited time, will avoid the two said events (collapse or dispersion).

Now the mass of universe, by some authors, is estimated [4]-[6] to be $M_u \cong 10^{53}$ kg; the same order of magnitude is given through the number ($\cong 10^{22}$) of observable stars [7] [8], and since from Earth the distribution of the masses appears to be homogeneous and isotropic, under our assumption $U_\infty = 0$, we may assume their density as decreasing toward the infinity like a function $\rho = \rho_c e^{-as}$ with $\rho_c \cong 9.2\times 10^{-27}$ kg/m^3 the *critical density* [9]. So the mass of universe can be written

$$M_u = \int_0^\infty 4\pi s^2 \rho_c e^{-as} ds = 4\pi\rho_c \int_0^\infty s^2 e^{-as} ds = \frac{8\pi\rho_c}{a^3} \cong 10^{53} \text{ kg} \tag{6}$$

yielding

$$a = \left(8\pi\rho_c / M_u\right)^{\frac{1}{3}} \cong 1.3\times 10^{-26} \text{ m}^{-1} \tag{7}$$

On Earth, the variation of potential due to an increase of the distance ds, can be written as $dU = -dmG/s$ where $dm = \rho 4\pi s^2 ds$ with $\rho = \rho_c e^{-as}$, hence the potential on Earth becomes

$$U_0 = -\int_0^\infty \left(4\pi s^2/s\right) G\rho_c e^{-as} ds = -4\pi\rho_c G \int_0^\infty e^{-as} s ds = -4\pi\rho_c G/a^2 \cong -4.5\times 10^{16} \text{ J} \tag{8}$$

Now, according to (5), on Earth it is

$$u_o = \sqrt{-2U_o} \cong \sqrt{9\times 10^{16}} \cong 3\times 10^8 \text{ m/s} \tag{9}$$

Therefore, on Earth, $u_o = c_o$, so that $\frac{1}{2}c_o^2 = -U_o$ and, in general we may argue

$$c = \sqrt{-2U} = u \tag{10}$$

The equality $c = u$, which implies the massiveness of light, means that, along any free path, the speed of light only depends on the value of the potential along that path.

[As for the relation $c_o^2 = -2U_o$, the Harvard tower experiment has shown that the fractional change in energy (of light) is given by $\delta E/E = -gh/c^2$, and since the term gh is the variation of potential from the ground to the height h, we may guess that c^2 has to be related to the total gravitational potential, as also shown on §6].

3. Annual Variation, on Earth, of the Total Escape Speed

On Earth a small variation of the total escape speed u_o, from (9), can be written as

$$\Delta u = \Delta U / u_o \tag{11}$$

where ΔU is the variation of the total potential on Earth, mainly due to the variable distance Earth-Sun.

So considering the eccentricity e (=0.0167) of Earth's orbit around the Sun, between their average distance d (=1.5×10^{11} m) and their shortest distance (Perihelion) $p = (1 - e)d$, and with $u_0 = 3 \times 10^{8}\ \text{m}\cdot\text{s}^{-1}$, the (11) gives

$$\Delta u_e = -\frac{\Delta U_S}{u_o} = \frac{\left[\left(\frac{M_S G}{p}\right) - \left(\frac{M_S G}{d}\right)\right]}{u_o} = +0.05\ \text{m}\cdot\text{s}^{-1} \tag{12}$$

with Δu_e the variation of u due to Earth's orbit eccentricity, ΔU_S the variation of potential on Earth due to Sun between the two said distances, with M_S the mass of Sun. Hence from Aphelion to Perihelion, one should find Δu_{AP} (=Δc_{AP}) = $+0.10\ \text{m}\cdot\text{s}^{-1}$ and we note that this variation is compatible with the accuracy of the measured value of $c = 299792458\ \text{m}\cdot\text{s}^{-1}$. Due to Earth's rotation, there is also a daily variation which, from midnight to noon, is of the order of $\Delta u_r \cong 2 \times 10^{-4}\ \text{m}\cdot\text{s}^{-1}$; so, **on Earth**, u_o **is practically constant** during one year, as it is for the measurements of the speed of light.

4. Invariance of *c* for a Particular Particle, Here Defined, and Related Doppler Effect

Here we show that the Galileo's velocities composition law, (related to point-particles), cannot be correctly applied to a *particle*, (hereafter called *photon*), defined as follows:

"Longitudinally-extended, elastic non divisible particle emitted at speed u by a source during an emission time T, and moving along one ray (continuous succession of *photons*), where two consecutive *photons* cannot be separated along a free path (constraint of non separation)".

Of course, more *photons* emitted during an emission time T need an equal number of rays.

Calling *front* and *tail* the extremities of a *photon*, the *constraint of non separation* implies that, along a ray, any *tail* corresponds to the *front* of the next *photon*.

Referring to **Figure 1(a)** (where E_p is the location of S at $t = 0$ and S_T its location at $t = T$), since the escape velocity $\mathbf{c}$ (=$\mathbf{u}$) of an emitted *photon* (AB) is referred to the *Centre of potential* C_p, during its emission time ($0 \leq t \leq T$), the term $\mathbf{v}_{\text{CpA}} = \mathbf{u}$ should appear as the velocity of its front (A) from C_p.

The source S may have a velocity $\mathbf{v}_{\text{CpS}}$ from C_p, thus writing $\mathbf{v}_{\text{CpA}} = \mathbf{v}_{\text{CpS}} + \mathbf{v}_{\text{SA}}$ we should find $\mathbf{v}_{\text{SA}} = \mathbf{u} - \mathbf{v}_{\text{CpS}}$; this means that each *photon* emitted around the source should have a length $\lambda' = |\mathbf{v}_{\text{SA}}T| = |(\mathbf{u} - \mathbf{v}_{\text{CpS}})|T$ depending on $\mathbf{v}_{\text{CpS}}$, but this is contrary to the experience showing that if the source is fixed to its *initial* Emission point E_p (that is the point where S is located at the start of the emission) the emitted *photons*, referring to E_p, have equal characteristics. Thus, during the emission of a *photon*, the velocity of its front, (to comply with these *equal characteristics*), has to be referred to the *initial* Emission point E_p, therefore, see **Figure 1(b)**, where E_p is our reference frame, as for the front A, for definition, we have

$$\mathbf{v}_{\text{EpA}} = \mathbf{u} \tag{13}$$

[This condition also allows the *whole photon* to have a velocity $\mathbf{u}$ referred to C_p, as shown on **Figure 1(d)**].

Now the velocity of the front A, with respect to S, from (13), becomes

$$\mathbf{v}_{\text{SA}} = \mathbf{v}_{\text{SEp}} + \mathbf{v}_{\text{EpA}} = \mathbf{u} - \mathbf{v}_{\text{EpS}} \tag{14}$$

and still referring to **Figure 1(a)**, (where S_T is the location of S at $t = T$), should S be fixed to E_p (that is $\mathbf{v}_{\text{EpS}} = 0$), the length λ of each *photon*, after the emission time T, from (14) becomes $\lambda = v_{\text{SA}}T = uT$, while, in general, it is

$$\boldsymbol{\lambda}' = \mathbf{v}_{\text{SA}}T = \left(\mathbf{u} - \mathbf{v}_{\text{EpS}}\right)T = \boldsymbol{\lambda} - \mathbf{v}_{\text{EpS}}T \tag{15}$$

where $\boldsymbol{\lambda}'$ is the *photon* AB emitted with the source in motion from E_p.

Referring now to **Figure 1(c)**, if a generic Observer O is our Reference frame, we can write

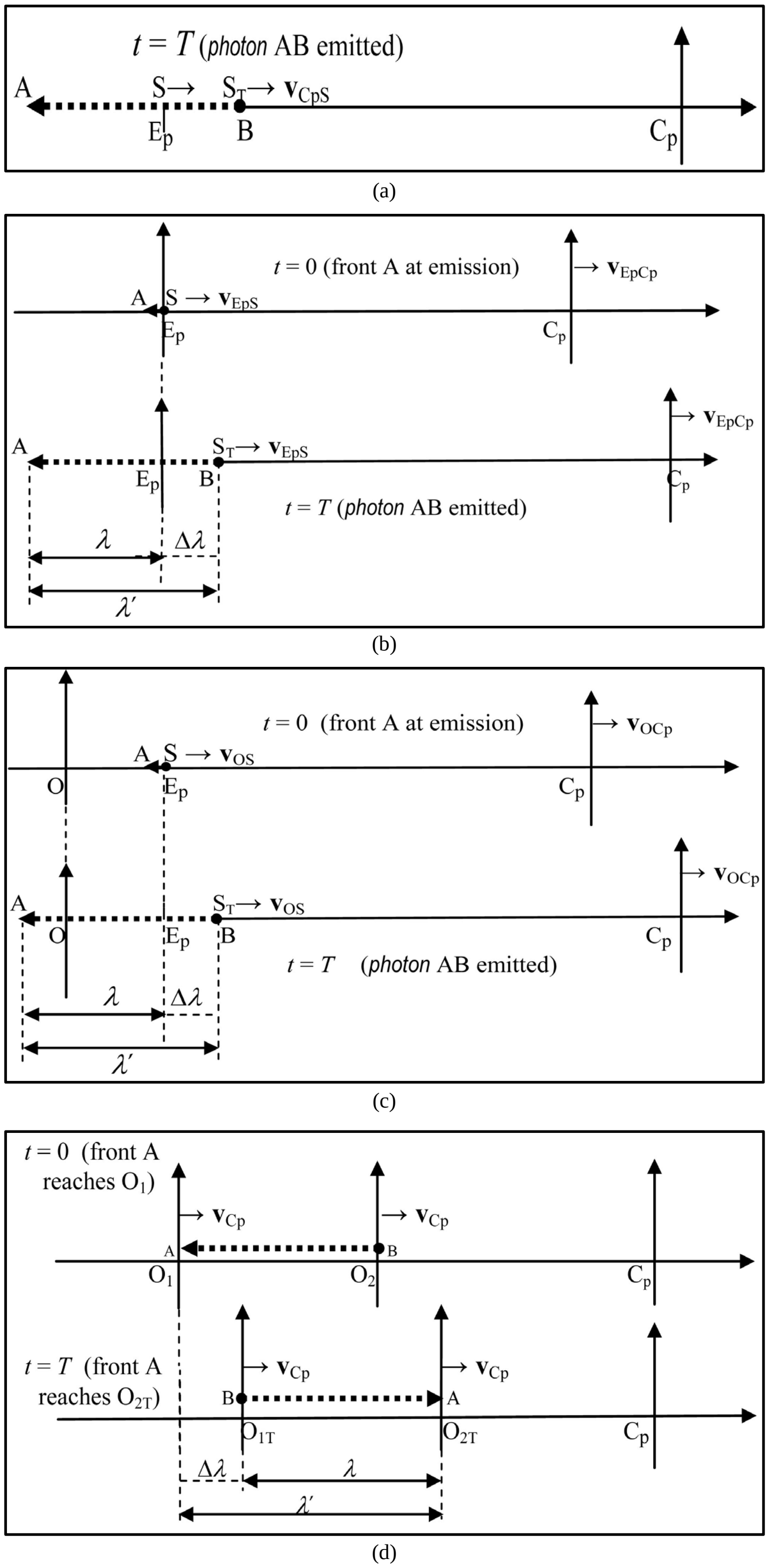

Figure 1. (a) *Photon* AB emitted under the supposed condition $\mathbf{v}_{CA} = \mathbf{u}$; (b) Emission of a *photon* AB referred to the initial Emission point E_p; (c) Emission of a *photon* AB referred to the generic Observer O; (d) Measurement of the speed of a *photon* (AB) reflected by O_1.

$$\boldsymbol{\lambda}' = \mathbf{v}_{SA}T = \left(\mathbf{v}_{SO} + \mathbf{v}_{OEp} + \mathbf{v}_{EpA}\right)T = \left(\mathbf{v}_{SEp} + \mathbf{u}\right)T = \boldsymbol{\lambda} - \mathbf{v}_{EpS}T \tag{16}$$

where $\boldsymbol{\lambda}'$ is the *photon* emitted while the source is in motion, with velocity $\mathbf{v}_{OS}$, from the Observer, and once more, if $\mathbf{v}_{EpS} = 0$ (S fixed to E_p), we find $\lambda' = \lambda = uT$ (If S is now our Reference frame, and $\mathbf{v}_{EpS}$ is the velocity of S from E_p, we still have the (15)).

Thus, after the emission time T, as for a source receding from the front of the considered *photon*, as in **Figure 1(b)** (or **Figure 1(c)**), the length λ' (for any Observer) turns out to be

$$\lambda' = uT + vT = \lambda + \Delta\lambda = \lambda(1+\beta) \tag{17}$$

where v ($=|\mathbf{v}_{EpS}|$) is the speed (referred to E_p) of the source S (along the direction E_pS), $\Delta\lambda$ ($=vT$) is the path covered by S during T, and where $\beta = v/u$, and we point out that the length λ' may change, along a free path, and under constant potential, only during its emission.

Now, the speed of a *point-particle* is defined through two Observers, while the speed u' of a *photon*, because of its variable length during its emission, does not correspond to the speed of any point of it, hence we must consider its length referred to the time T' (*transit time*) the *photon* (front to tail)needs to cross one Observer, so it has to be defined

$$u' = \left|\boldsymbol{\lambda} - \mathbf{v}T\right|/T' = \lambda'/T' \tag{18}$$

[As for this definition, let us consider a system composed of two balls connected through an elastic thread and let them fall in vertical line: during the fall, each part of the system has different speed, so we define the speed of the *whole* system according to Equation (18)].

Returning now to **Figure 1(c)**, for the Observer O, the *transit time* T' of the *photon* AB is given by the time the front A spend to cover the path λ, that is $T(\lambda/u)$, plus the time the tail B needs to cover the path $S_T - E_P = \Delta\lambda$; now, once the *photon* AB has been emitted (at $t = T$), the velocity of the front A has to be the same as any other part of the emitted *photon*, hence the time needed by B to cover the path $\Delta\lambda$ is $\Delta T = vT/u$, giving

$$T' = T + \frac{\Delta\lambda}{u} = T + \frac{vT}{u} = T(1+\beta) \tag{19}$$

Now, according to (18), the speed of the *photon* AB, referred to O, becomes

$$u' = \frac{\lambda'}{T'} = \frac{\lambda(1+\beta)}{T(1+\beta)} = u \tag{20}$$

showing that the speed of *photons* emitted by a source S is invariant for any Observer, in spite of any speed of S with respect to the Observer [After the emission, each part of the *photon* has same velocity $\mathbf{u}$, meaning that, during the emission, it is the velocity of its inner part to vary in order to change its length in the given time T].

As for an emitted *photon*, the measurement of c (through the method *d/t*) implies its absorption and reflection by an Observer. In this way, the Observer becomes the source of a new *photon*, with the Observer/Source located in the Emission point E_p, so we may refer to **Figure 1(b)**, with the source fixed in E_p, finding $u' = \lambda/T = u$.

[Anyhow, we may obtain the same result ($u' = \lambda'/T' = \lambda/T = u$) as follows:
the measurement of c (through the method *d/t*) implies two Observers at a constant relative distance O_1O_2; on these bases, see **Figure 1(d)** where C_p is now our Reference frame, after the reflection of the *photon* from O_1, at $t = T$, the *path* covered by the front A to reach O_{2T} is given by O_1O_{2T} that is $\lambda' = \lambda + \Delta\lambda$ where λ is the *length* of the emitted *photon* AB and where $\Delta\lambda = v_{Cp}T/c$, with v_{Cp} the speed of our frame O_1O_2 with respect to C_p, yielding $\lambda' = \lambda(1 + \beta)$ where $\beta = v_{Cp}/c$. The time needed by the front A to cover the distance O_1O_{2T} is $T' = T + \Delta\lambda/c = T(1 + \beta)$, thus the measured speed (referred to the two Observers) becomes $c' = \lambda'/T' = \lambda/T = c$ in spite of any velocity of the co-moving Observers O_1 O_2 with respect to C_p (Anyhow, the Observer O_1 could state, for the front A, a velocity $\mathbf{v}_{O_1A}$ different from $\mathbf{u}$, if he could measure such a speed)].

For any Observer, **the frequency** of *photons* of the same ray has to be defined as $\nu' = n/t$ with n the number of *photons* crossing the Observer during a time t; for $t = T'$ (*transit time* of one *photon*), it is $n = 1$, thus $\nu' = 1/T'$, so from (19) we get

$$\nu' = \frac{1}{T'} = \nu/(1+\beta) \tag{21}$$

showing that for $v = 0$, that is $\beta = 0$, we have $\nu' = \nu$, which is also valid if the Observer (O) and the source (S) belongs to different potential: in fact, for O and S at reciprocal rest, the number of *photons* emitted by S in a unit time has to be equal, in the same time, to the number of them crossing O (like, for instance, the number of balls falling from the top of a tower with respect to an Observer at the tower base), and this implies $\nu_s = \nu_o$.

Now, the **Figure 1(c)**, where a source emits a *photon* while it is in motion from the Observer O, also represents a longitudinal Doppler effect, which, in general, can be written a

$$\lambda' = \lambda(1 \pm \beta); \quad \nu' = \nu/(1 \pm \beta) \tag{22}$$

with the sign + for S receding from the Observer, while the sign – is for S approaching it.

Hereafter we get our equations regarding both the generic and the transverse Doppler effect, followed by our relations regarding a source (of light) circling around an Observer.

To get a general relation for the Doppler effect, let us consider, see **Figure 2(b)**, referring to the Observer O, a source S, located in E_p (at $t < 0$), at rest with O. During this time let S emit *photons* having length λ (=uT) and let $E_pO = \lambda$. Then, at $t = 0$, let S start to move from E_p toward S_T (reached at $t = T$), with velocity $\mathbf{v}$ (referred to O) along the generic direction a-a. Now, during the path E_pS_T, let S emit a *photon* $\boldsymbol{\lambda}'$ toward O. (On **Figure 2(a)**, the small arrow inside the triangle E_pOS_T represents the partial $\boldsymbol{\lambda}'$ during its emission.) At $t = T$ (end of emission), according to (16) we have $\boldsymbol{\lambda}' = \boldsymbol{\lambda} - \mathbf{v}T$, thus the length of $\boldsymbol{\lambda}'$, assuming $v \ll u$, so to consider $E_pO = NO$, with $E_pN \perp S_TO$, becomes

$$\lambda' = \lambda + vT\cos\alpha = \lambda(1 + \beta\cos\alpha) \tag{23}$$

As for the transit time T', as before, we can write $T' = T + \Delta\lambda/u = T + (vT\cos\alpha)/u$.

which can also be obtained considering that the front of $\boldsymbol{\lambda}'$, following the tail of $\boldsymbol{\lambda}$ (thus directed toward O), takes a time T to reach O from E_p, while the tail of $\boldsymbol{\lambda}'$, emitted in S_T, has to cover the path $S_TO = S_TN + NO$, spending the time $\Delta T = (vT\cos\alpha)/u$ for the path S_TN, plus the time T for the path NO (equal to E_pO for $v \ll u$), giving

$$T' = T + \left(\frac{vT}{u}\right)\cos\alpha = T(1 + \beta\cos\alpha) \tag{24}$$

yielding

$$\nu' = \nu/(1 + \beta\cos\alpha) \tag{25}$$

thus $u' = \lambda'/T' = \lambda/T = u$ (For an opposite direction of S we get $\lambda' = \lambda(1 - \beta\cos\alpha)$ and $T' = T(1 - \beta\cos\alpha)$.

[*Ray* $S_{2T}FO$: referring now to **Figure 2(b)**, if S, between T and $2T$, is still moving with same velocity $\mathbf{v}$, the emitted *photon* $\boldsymbol{\lambda}''$ will have same length as $\boldsymbol{\lambda}'$, thus its front (at $t = 2T$) will reach a point F, (corresponding at the same time to the tail of $\boldsymbol{\lambda}'$), at a distance $FO = S_{2T}N = vT\cos\alpha$ from O, so the *ray* Source-Observer, at $t = 2T$, becomes the line $S_{2T}FO$].

Transverse Doppler effect: referring to **Figure 3(a)** left part, where $S_TO \perp E_pS_T$, should S start to move at $t = 0$ from E_p to S_T while emitting the *photon* $\boldsymbol{\lambda}'$, according to (16) we can write

$$\lambda' = \sqrt{\lambda^2 - (vT)^2} = \lambda\sqrt{1 - \beta^2} \quad \text{(valid for S approaching O)} \tag{26}$$

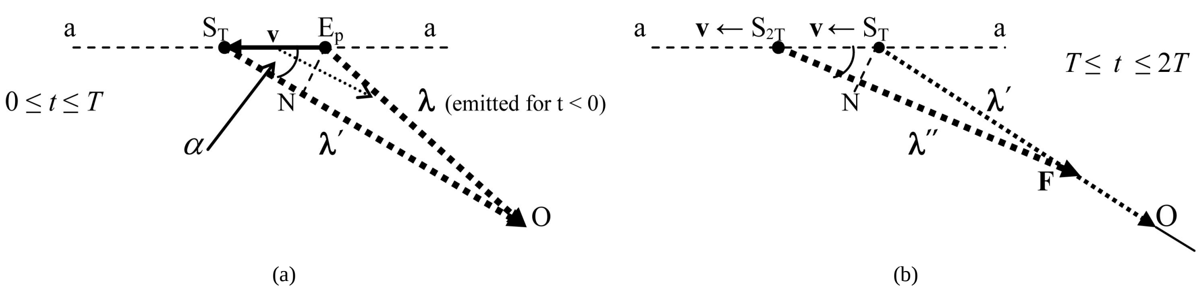

Figure 2. Doppler effect for a *photon*, general case.

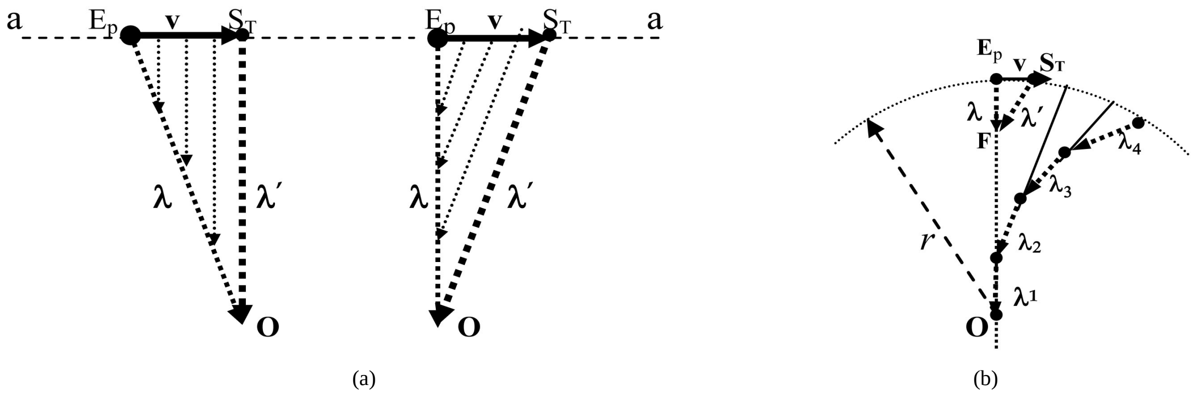

Figure 3. (a) Transverse Doppler effect; (b) Source circling around the Observer O.

where λ' is the length corresponding to S_TO, while λ corresponds to E_pO. On the contrary, see **Figure 3(a)** right part (where the source is receding from the Observer), it will be

$$\lambda' = \sqrt{\lambda^2 + (vT)^2} = \lambda\sqrt{1+\beta^2} \quad \text{(valid for S receding from O)} \tag{27}$$

Then $T' = T + \frac{\Delta\lambda}{u} = T + \frac{\lambda' - \lambda}{u} = T + (\lambda'/u) - \frac{\lambda}{u} = \lambda'/u = \lambda\sqrt{1+\beta^2}/u$, hence $c' = c$.

Regarding a source circling around an Observer O, on **Figure 3(b)** the line E_pO represents a succession of *photons* **λ** already emitted when S is fixed in E_p, while E_pF represents the last of them (or it could represent the last *photon* emitted by S when reaching E_p). Then, at $t = 0$ let S start to move from E_p with velocity **v** toward S_T.

Now, because of the *constraint of non separation*, the front of the first *photon* $\boldsymbol{\lambda}'$ emitted when S is moving between E_p and S_T, has to reach, in F, the tail of previous *photon*, so, according to (16) the length of every *photon* $\boldsymbol{\lambda}'$ (emitted while S is moving along the orbit *r*) will be

$$\lambda' = \sqrt{\lambda^2 + (vT)^2} = \lambda\sqrt{1+\beta^2} = \lambda\sqrt{1+\omega^2 r^2/c^2} \tag{28}$$

thus

$$T' = T\sqrt{1+\beta^2} = T\sqrt{1+\omega^2 r^2/c^2} \tag{29}$$

with *r* the orbit radius, ω the angular speed, giving to any **whole** *photon* the speed $c' = c$.

Figure 3(b) also shows a path ($\boldsymbol{\lambda}_1$-$\boldsymbol{\lambda}_4$) of a ray directed toward O (the lines connecting the *photons* $\boldsymbol{\lambda}_2$ and $\boldsymbol{\lambda}_3$ to the orbit give the point where the source is located at the end of their emission).

5. Physical Characterization of These Photons

Now, similarly to a fluid flowing in a pipe (whose kinetic energy is $K = \frac{1}{2}mv^2$ with *m* the mass passing in 1 s), the kinetic energy of light flowing along one ray (according to our definition, ***photons* are also massive**), has to be expressed with $K_c = \frac{1}{2}mc^2$ with *m* the mass of the particles passing in 1 s along one ray. Anyhow, the *total* energy of light flowing along one ray is $E = mc^2$ as also proved by the evidences of nuclear reactions like $n + p \rightarrow d + \gamma$: indeed, in this reaction [10], the lost mass, known through mass spectrometers, corresponds to the value $m = E/c^2$ where E ($=hc/\lambda$), (as λ is measured), is also known, so $E = mc^2$ represents the *total* energy of light flowing along one ray (λ_{meas} is obtained [11] through the value $\lambda_{meas}/(d_{220})$ given at pag. 369, where (d_{220}) is given at page 410).

So, writing $E = \frac{1}{2}mc^2 + \frac{1}{2}mc^2$ we may infer that each of these *particles* is provided with an *internal* energy ($K_i = \frac{1}{2}mc^2$) equal to its kinetic energy. Now, equating mc^2 to $h\nu$ we get

$$mc^2 = h\nu\left(=E\right) \tag{30}$$

where m written as

$$m = \frac{h\nu}{c^2} \equiv \gamma\nu\ (\text{kg}) \tag{31}$$

is the mass of light, with frequency ν, passing along one ray in 1 s, while the constant

$$\gamma \equiv h/c^2\left(=m/\nu\right) = 7.372495\times10^{-51}\ \text{kg}\cdot\text{s} \tag{32}$$

is the mass of light passing *along one ray* during T, we may call it "mass of one *photon*"; so one finds

$$h = \gamma c^2 = mc^2T \tag{33}$$

and therefore the **Planck's constant *represents the energy of one photon***. The energy of these particles passing in 1 s along one ray (*energy of one ray of light*) can now be written as

$$E = K_c + K_i = \frac{1}{2}mc^2 + \frac{1}{2}mc^2 = mc^2 = h\nu = \gamma c^2\nu \tag{34}$$

On the above bases, the total energy of light emitted by a source is given by $n_r mc^2$ with n_r the number of rays, and since m is the mass of light passing along one ray in 1 s, this unitary (for unit of time) energy shall be equal to the supplied power P during 1 s, thus $n_r mc^2 = P$, hence the total **mass lost per second** m_T ($\equiv n_r m$) **by a source of light** becomes

$$m_T = n_r m = P/c^2 \tag{35}$$

So, for a 1 W lamp, we get $m_T = P/c^2 \cong 1.1\times10^{-17}$ kg·s^{-1}, while **the number** n_r **of rays** is

$$n_r\left(=m_T/\gamma\nu\right) = P/c^2\gamma\nu = P/h\nu \tag{36}$$

in our case, $n_r \cong 3\times10^{18}$ rays. **We point out** that for a given power P, the higher is the frequency, the lower is the number of rays, as shown by (36) written as $n_r\nu = P/h$. **The number of *photons* emitted in 1 s** becomes:

$$n_\gamma\left(=n_r\nu\right) = P\nu/h\nu = P/h \tag{37}$$

which, for $P = 1$ W, gives $n_\gamma = h^{-1}$ ($=1.5\times10^{33}$ photons/s), so **the inverse of Planck constant** corresponds to the number of *photons* emitted in 1 s by a source of unitary power (This great number of *photons* (having emission time T at speed c) can be regarded as a wave function).

Now the momentum of the *photons* passing along one ray in 1s, considering their kinetic energy only, that is $K_c = \frac{1}{2}mc^2$, according to Newtonian mechanics should be written as

$$\mathbf{p} = m\mathbf{c} = \gamma\nu\mathbf{c} = \gamma\mathbf{c}/T \tag{38}$$

but considering both their kinetic and their internal energy, that is $E = mc^2$ we obtain

$$\mathbf{p} = 2m\mathbf{c} = 2\gamma\nu\mathbf{c} = 2\gamma\mathbf{c}/T = \left(\gamma\mathbf{c}/T\right) + \left(\gamma\mathbf{c}/T\right) \tag{39}$$

6. Revisitation of the Harvard Tower Experiment and Time Dilation

Referring to **Harvard tower experiment** [1]-[3], simply represented on **Figure 4**, where h is the tower height, calling c_0 the value of c on Earth's surface at the tower base and c_h its value on its top, the variation $c_h - c_o$) from the tower base to its top, from (11), for $c = u$, becomes

$$\Delta c = c_h - c_o = -\Delta U/c_o \tag{40}$$

where $\Delta U = \left(U_{Eh} - U_{E0}\right)$ is the variation of the total gravitational potential U, due to Earth, from the tower base to its top. As $U_{Eo} = -M_E G/r_o$ and $U_{Eh} = -M_E G/r_h$ where M_E is the Earth's mass and r its radius, we get $\Delta U = M_E Gh/r^2$ where h ($=r_h - r_o$) is the tower height, yielding

$$\frac{\Delta c}{c_o} = \frac{c_h - c_o}{c_o} = -\frac{M_E Gh}{r^2 c_o^2} = -gh/c_o^2 \tag{41}$$

showing that, on the top, where $|U_h| < |U_o|$, it is $c_h < c_o$, with $c_h = c_o\left(1 - gh/c_o^2\right)$.

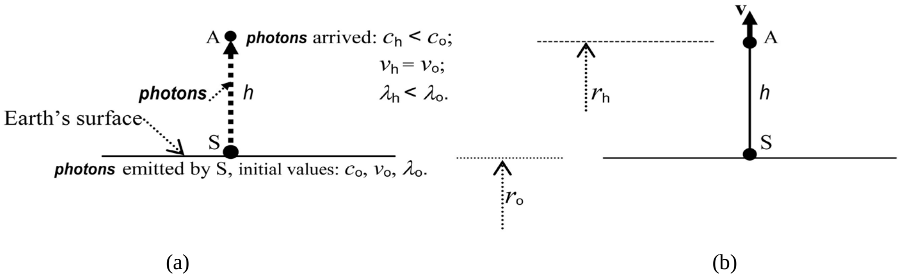

Figure 4. Harvard tower experiment scheme, with the source at the base. (a) S and A at rest at a different level h. In A, $\lambda_h < \lambda_o$, so the detector observes a gravitational blue-shift; (b) Source and absorber relative motion (**v**) to compensate the gravitational blue-shift through the Doppler effect.

Now, let S be a Mossbauer source and A an appropriate absorber; if they are close to each other (for instance, at the tower base), the absorber is in resonance with the source.

Then, see **Figure 4(a)**, with S at the tower base and taking A to its top, while S and A are at rest, the frequency of the emitted *photons* (*i.e.* the number of *photons* emitted along the direction SA per unit of time) has to be equal to the *photons* received by A, that is $\nu_h = \nu_o$ and since $c_h < c_o$, it must be $\lambda_h < \lambda_o$ (indeed $\Delta\lambda/\lambda_o = \Delta c/c_o$), so, *contrary to* ToR, a blue-shift effect for A.

[On **Figure 4(a)** (*photons* arrived to the top), according to $\nu_h = \nu_o$, it seems to be $E_h/E_o = h\nu_h/h\nu_o = 1$ (here h is the Planck constant), but the (33) shows that $h = \gamma c^2$ with γ (representing the mass of light passing during T along one ray), an effective constant, so that we get $E_h/E_o = (c_h/c_o)^2$ which shows a decrease of the energy of light from S to A].

Indeed, with S on the base emitting toward A on top, A goes out of resonance and since on our bases $\nu_h = \nu_o$, the *non-resonances physically related to a variation* of λ, whereas in the Harvard tower experiment [3], "no mention has been made of frequency or wavelength".

Thus, to restore the resonance through the Doppler effect (*i.e.* to increase the *photon* length fromits value λ_h in A to its initial value λ_o in S), since $\lambda_h < \lambda_o$, A and S, see **Figure 4(b)**, have to recede from each other with speed v complying with (17), here written $\lambda_o = \lambda_h + vT$, giving $(\lambda_h - \lambda_o)/\lambda_o = -vT/\lambda_o$.

Therefore, since $\Delta\lambda/\lambda_o = \Delta c/c_o$ (as $\nu_o = \nu_h$), we find $\Delta c/c_o = -vT/\lambda_o$ and comparing to (41) we get $-vT/\lambda_o = -gh/c_o^2$, so the relative speed between S and A becomes

$$v = gh/c_o = 7.5\times10^{-7}\ \text{m/s} \quad (\text{for } h = 22.5\ \text{m}) \tag{42}$$

[This value is also predicted by General Relativity (GR)which, implying a decrease of v for light moving from the base to the top, **predicts an opposite direction** of **v** with respect to the one shown on **Figure 4(b)**; at this regard, Pound-Rebka [3] operated in order to determine (through the value of v, obtained moving the source sinusoidally) the variation of energy of a beam on the upward and downward path, without any indication (because of the low value of v), about the direction of the compensating speed].

Now, if we take S to the tower top, with A located on its base (see **Figure 5** which is referred on our bases), the experiment shows that the absorber goes out of resonance.

Now, according to Relativity, taking S to the top, the initial frequency of the light should be $\nu_h = \nu_o$, which, on our bases, **is wrong**: with S on the top, see **Figure 5(a)**, the (10) written as $c^2 + 2U = 0$, between top and base gives $c_h^2 + 2U_h = c_o^2 + 2U_o$, where $U_h - U_0 = gh$, giving $c_0^2 = c_h^2 + 2gh$, then $c_0 = \left(1 + 2gh/c_h^2\right)^{1/2}$, and since $2gh \ll c^2$ we can write $c_o = c_h(1 + gh/c^2)$, that is $c_h < c_o$ as showed by (41), but what about ν_h and λ_h?

Well, referring to previous **Figure 4(a)**, with source S on the base, the length of *photons* arriving to the pvaries from λ_o to λ_h (with $\lambda_h < \lambda_o$), therefore if S has been taken now to the top, should their initial length be λ_h, at their arrival to the base, their length should be λ_o, and since the resonance, as seen, depends on λ, the Absorber A (on the base, see **Figure 5(a)**), should be now in resonance. Thus we can argue that taking the source on top, the *photons* initial length has to be λ_h ($=\lambda_o$); then, as $c_h < c_o$ as shown by (41), it must be $\nu_h < \nu_o$, and in particu lar, according to (41) we get $\Delta c/c_o = \Delta\nu/\nu_o = -gh/c_o^2$, giving $\nu_o = \nu_h\left(1 + gh/c_o^2\right)$ which is the same as the one predicted by GR, but on our bases, this variation is due to a different initial frequency (as the source is now on the top), whereas for GR this variation is related to the path of the emitted light between two different levels. (Indeed on our bases the frequency remains constant during any path, should source and observer be at recipro-

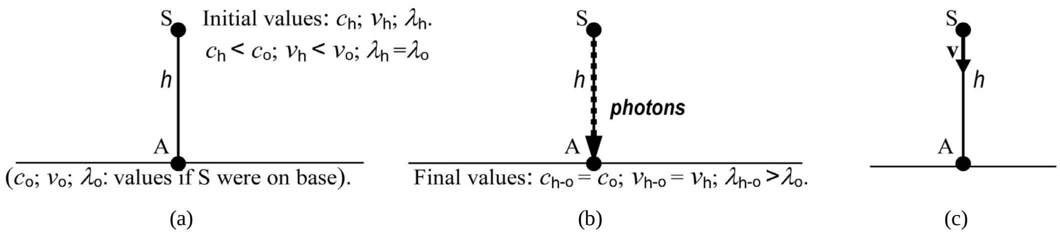

Figure 5. Harvard tower experiment scheme, with the source on the top. (a) S on top, S and A at rest: c_h, ν_h, λ_h are the *photons* initial parameters on the tower top; (b) S and A at rest. When *photons* reach the base, $\lambda_{h\text{-}o} > \lambda_o$, so A observes a g-redshift; (c) S and A relative motion to compensate the g-redshift via Doppler effect.

cal rest).

Thus, see **Figure 5(b)**, with S emitting from the top, S and A at rest, when the *photons* reach the base, as their final frequency ($\nu_{h\text{-}0}$) will remain the same as the initial one (that is $\nu_{h\text{-}o} = \nu_h$) and since $c_o > c_h$, it turns out that, along the path SA, λ will increase, and its variation, opposite to the one given by (41), yields now $\Delta\lambda/\lambda_o = gh/c_o^2$, giving $\lambda_{h\text{-}o} = \lambda_o\left(1 + gh/c_o^2\right)$.

Now, as $\lambda_{h\text{-}o} > \lambda_o$, the absorber, on the base, will observe a gravitational red-shift so, to compensate it via Doppler shift, see **Figure 5(c)**, S and A have now to move relative to each other in order to decrease the final length $\lambda_{h\text{-}o}$ to the resonance value λ_o; **on the contrary, according to ToR, A and S should recede from each other**.

[Still referring to **Figure 5**, taking S to the tower top, we have $c_h < c_o$ and $\nu_h < \nu_o$ implying, contrary to GR, a decrease of the energy of light to be emitted by S, $\left(E_h = h\nu_h = \gamma c_h^2 \nu_h\right)$, see (34), and therefore when these *photons* reach the base (where $c_{h\text{-}o} = c_o$) their energy becomes $E_{h\text{-}o} = \gamma c_o^2 \nu_h$ giving a reason to the loss of energy as for light arriving to Earth coming from sources located in points where $|U_S| < |U_o|$, and since, as seen, $\lambda_{h\text{-}o} = \lambda_o\left(1 + gh/c_o^2\right)$, we also give a cosmological reason to the high redshift of sources where $|U_S| \ll |U_o|$.

Time Dilation

Well, the experience shows that, on board of GPS satellites, the atomic clocks run faster by about 38 μs/day than the ones on ground, meaning that, in altitude, their ticking time, (or interval time, intending the minimum time counted), is shorter than the one on ground.

Now, the ticking time t of atomic clocks is proportional to their frequency, so on ground we can write $t_0 = k\nu_0$ while in altitude $t_h = k\nu_h$ yielding $\Delta\nu/\nu_o = \Delta t/t_o$ where Δt $(= t_h - t_o)$ is the ticking time variation from ground to height h, with $\Delta\nu$ $(= \nu_h - \nu_o)$ representing their frequency variation due to the gravitational potential variation.

Now, taking the sources (clocks) from ground to height h, the length of their *photons*, at emission, remains constant, ($\lambda_h = \lambda_o$), thus, because of the variation of c (from ground to height h), it has to correspond an equal variation of ν, so that the (40) can be written as

$$\Delta c/c_o = \Delta\nu/\nu_o = \Delta t/t_o = -\Delta U_E/c_o^2 \tag{43}$$

Now, GPS satellites have an orbit of r_h 26,600 km, that is an altitude h 20,200 km, as r_o 6400 km is the Earth's radius. Hence, the (43), **because of the variation of the potential, the variation of the counted time during one day** (Δt_{1d}), since in one day t_{1d} = 86,400 s, gives

$$\Delta t_{1d} = -\left(\frac{\Delta U_E}{c_o^2}\right)t_{1d} = -\left[\frac{M_E G\left(r_h - r_o\right)}{r_h r_o c_o^2}\right]86,400 = -45.6\ \mu\text{s} \tag{44}$$

where the sign means that the ticking time is decreasing, inducing the clocks to run faster. Then we have to take into account that the parameters of the *photons* emitted by atomic clocks on board of GPS satellites are changing because they are circling around the Earth.

Therefore, according to (29), that is $T' = T(1 + \beta^2)^{1/2}$ where T' is the time a *photon* needs to cross the Observer, during one day (86,400 s), since the orbital speed corresponds to two orbits every day (giving $v = 2(2\pi r_h/86,400)$

$= 3870\ \text{m}\cdot\text{s}^{-1}$, and considering that for $v \ll c$ we can write $(1+\beta^2)^{1/2} \cong 1 + \beta^2/2$, we get

$$\Delta t'_{1d} = (T' - T)86,400 = (\beta^2/2)86,400 = 7.2\ \mu\text{s} \tag{45}$$

representing the variation of the counted time in one day due to the orbital speed of GPS satellite, and since this variation is positive, it has to be deducted from the negative one due to the potential variation, thus the *total variation of the counted time* on **GPS** satellites, in one day, becomes

$$\Delta t_{\text{day}} = \Delta t_{1d} + \Delta t'_{1d} = -38.4\ \mu\text{s/day} \tag{46}$$

as observed. This equality also confirms that $\lambda_h = \lambda_o$ as for sources in altitude.

7. Red Shift

According to the Relativity, the *gravitational* red shift of light coming from the Sun, with M_S and R_S its mass and radius, is $z_S \cong M_S G / R_S c^2 = 2\times10^{-6}$. Now, for $s <\cong 20$ Mpc, with s the distance Earth-source, the observed shifts are in the range $z \cong \pm10^{-2}$ [12], while from $\cong 20$ to $\cong 40$ Mpc they tend to become always positive, and between $\cong 40$ and $\cong 900$ Mpc ($\cong 3$ Bly) the red shifts (here in the range $\cong 0.01$ - 0.20), practically follow the empirical Hubble's law $z = H_o s/c$; hence, since the value of the *gravitational* red shifts of a typical galaxy, intended to be $z_g \cong M_g G / R_g c^2$, should be of the order of 10^{-9}, the Doppler effect appears to be (as for the Relativity), the only satisfactory way to explain the observed blue shifts and also the high (cosmological) red shifts.

On the contrary, on our basis, disregarding any motion between a source and an Observer on Earth, which implies (as showed on §4) $\nu = \nu_o$, we get $c/\lambda = c_o/\lambda_o$, where ν_o, c_o and λ_o are observed on Earth, showing that for $c_o > c$, it has to be $\lambda_o > \lambda$. Hence, the blue/red shifts observed on Earth can be expressed as

$$z \equiv \Delta\lambda/\lambda = \Delta c/c = (c_o - c)/c = (c_o/c) - 1 = \sqrt{U_o/U_s} - 1 \tag{47}$$

where $U_0\left(= -\frac{1}{2}c_0^2\right)$ is the potential on Earth, while U_s the one on the source (at distance s). Thus the shift of a far source, disregarding the motion source-Earth, turns out to be the variation of c (as well as λ) during the path of light toward a different potential; *for instance*, going from Earth to Sun, and considering that along this path the main variation of potential ($\Delta U_{(s)}$) is due to the Sun only, we can write $U_S = U_o + \Delta U_{(s)}$ where

$$\Delta U_{(s)} = -(M_s G/R_s) + (M_s G/d) \cong -M_s G/R_s \tag{48}$$

With d the distance Earth-Sun; so ***on the Sun***, $c_s = \sqrt{-2U_s} = \sqrt{-2\left(U_o + \Delta U_{(s)}\right)}$ and then

$$c_s = \sqrt{c_o^2 + 2M_s G/R_s} \cong c_o\left(1 + \frac{M_s G}{R_s c_o^2}\right) = c_o + 635\ \text{m}\cdot\text{s}^{-1} \tag{49}$$

giving $\Delta c/c = z \cong 2.1\times10^{-6}$, while on the opposite path, Sun to Earth, it is $z \cong 2.1\times10^{-6}$, hence a blueshift (contrary to a red shift of the same value predicted by the Relativity).

As for $s <\cong 40$ Mpc, according to (47), if U_s (potential on the source) is, in *absolute value*, higher than the potential on Earth U_o, we get, on Earth, $z < 0$ (blue shift), and vice versa for $|U_s| < |U_o|$, hence, apart Doppler effects, these red/blue shifts indicate that the potential, from Earth to the sources in this space, may increase or decrease (and since for $s >\cong 40$ Mpc, z is positive, we may also argue that our galaxy is close to the middle of the masses of universe); then, over this distance, it turns out that, on the related sources, U_S is (in absolute value), always lower than U_o, and also tending to zero for $z \to \infty$.

In the range $\cong 0.01 < z <\cong 0.20$ (where z follows the Hubble's law), the (47), written as

$$U_s = U_0 / (1+z)^2 \tag{50}$$

for $z \ll 1$ gives $U_s \cong U_o/(1+2z)$ yielding (through a simple artifice) to

$$U_s \cong U_o(1-2z) \quad \text{(valid for } z \ll 1\text{)} \tag{51}$$

which shows that, for $z \ll 1$, U_s depends linearly on z; in particular, **Table 1** shows that, in the said range

Table 1. Calculated values of U and c related to the observed redshifts on Earth. The 4th column is referred to Equation (50); the 5th to (51); the 6th to (47).

Redshift z	$s = zc/H_o$ Mpc	1 Mpc 3.3×10^6 ly light years	$U_s/U_o = 1/(z+1)^2$	$U_s/U_o = (1-2z)$	$c_s/c_o = 1/(z+1)$
< |0.01|	<43	<140 Mly	0.98 - 1.02	0.98 - 1.02	0.99 - 1.01
0.01	43	140 Mly	0.98	0.98	0.99
0.05	215	700 Mly	0.90	0.90	0.95
0.20	860	2.8 Bly	0.69	0.60	0.83
1.0			0.25		0.50
5.0			0.028		0.17
9.0			0.010		0.10

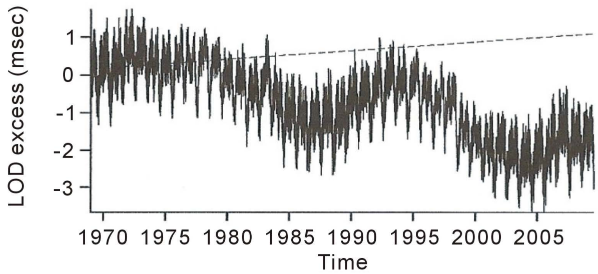

Figure 6. Length of day since 1969, when Earth-Moon laser ranging data started to be collected. The dotted line shows the 2.3 msec·cy^{-1} trend expected as a consequence of momentum conservation, when it is assumed that, using laser ranging, an actual increase of Earth-Moon distance is measured. LOD data comes from the EOP 05. C04 series (Bizouard and Gambis 2009), as provided by the Earth Orientation Centre (http://hpiers.obspm.fr). The Figure has been taken from the paper of Sanejouand, Y.H., *Empirical evidences in favour of avarying-speed-of-light*, arXiv 0908.0249.

($\cong 0.01$ - 0.20), the values given by (51), are practically the same as the ones given by (50). **Table 1** also shows the values of U and c for various values of z.

8. Conclusions

We showed that, on our basis, c corresponds to the *total* escape speed u which is practically constant on Earth (see §3), while the annual variations of c, due to the eccentricity of the Earth's orbit, are well shown on following **Figure 6**.

In fact, when the Earth (on perihelion) approaches the Sun, because of the distortion of the shape of Earth, the angular speed of Earth should decrease, hence, the length of day (LOD)should increase; moreover, during the approach Earth-Sun, due to the increase of the absolute value (on Earth) of U, the speed of light (on Earth) has also to increase, thus the LOD and c should show, at the same time, annual peaks, as shown on **Figure 1**, which **may also represent, in another scale, the annual variations of the speed of light, since 1969**.

Now ***we point out our attention on Compton effect***: indeed, through the *relativistic* Doppler effect equations, one *cannot* get the Compton equation (which can be found in other ways), whereas through our Doppler effect Equation (17), we can obtain it; well, one can observe that the Compton effect is not a Doppler effect, but *in this case why we get the Compton equation*? Is it a coincidence or the relativistic Doppler effect equations are not correct?

Finally, regarding the Harvard tower experiment, the Relativity, as for the *compensating speed* source-Observer (in order to restore the resonance between them), predicts opposite directions with respect to the ones we have obtained: we hope that now (after 50 years from the related experiment) an appropriate (similar) experiment will give a sure answer.

References

[1] Pound, R.V. and Rebka Jr., G.A. (1960) *Physical Review Letters*, **4**, 337. http://dx.doi.org/10.1103/PhysRevLett.4.337

[2] Pound, R.V. and Snider, J.L. (1964) *Physical Review Letters*, **13**, 539. http://dx.doi.org/10.1103/PhysRevLett.13.539

[3] Pound, R.V. and Snider, J.L. (1965) *Physical Review*, **140**, B788. http://dx.doi.org/10.1103/PhysRev.140.B788

[4] Kragh, H. (1996) Cosmology and Controversy. Princeton University Press, Princeton, 212.

[5] Gogberashvili, M., *et al.* (2012) Cosmological Parameter. ArXiv:physics.gen-ph, 2.

[6] Immerman, N. (2001) Nat'l Solar Observatory: The Universe. University of Massachusetts, Sunspot.

[7] Gott III, J.R., *et al*. (2005) *The Astrophysics Journal*, **624**, 463-484.

[8] Van Dokkum, P. (2010) *Nature*, **468**, 940-942. http://dx.doi.org/10.1038/nature09578

[9] Schutz, B.F. (2003) Gravity from the Ground Up. Cambridge University Press, Cambridge, 361. http://dx.doi.org/10.1017/CBO9780511807800

[10] Halliday, D. and Resnic, R. (1981) Fundamental of Physics. John Wiley & Sons, New York.

[11] Mohr, P.J. and Taylor, B.N. (2000) *Review of Modern Physics*, **72**, 351-495.

[12] (Yearly) NASA Extragalactic Database.

Appendix A (Compton Effect)

Here, see **Figure A1**, an incident ***photon*** (length λ, frequency ν), ejects a circling electron (m_e) but there is also a reflected *photon* (length λ' frequency ν') so the electron, while emitting a *photon* λ' toward the Observer A, represents a source in motion from A along the direction **w**, thus (considering the component $\mathbf{w}_A$ of **w**) there is an *indubitable* Doppler effect.

Now, on the basis that the scattered *photon* starts to be reflected at the same time when the incident *photon* starts to hit the electron, and since T' (=1/ν') is the emission time of the *photon* ν', it turns out that T' is also the whole interaction time, meaning that there is not a complete absorption of the incident *photon* followed by an emission: this means that the *internal* energy of the *photon* is not involved in this action, hence the momentum transferred from the *incident* light to the electron is $\mathbf{p} = m\mathbf{c}$ (=$\gamma\mathbf{c}/T$) as per (38), and the same value $\mathbf{p} = m\mathbf{c}$ is the momentum transferred from the scattered *photon* to the electron.

Therefore, the Conservation of Momentum (CoM) along the direction normal to **w**, becomes $(\gamma c/T')\sin\theta = (\gamma c/T')\sin\theta'$ giving $\theta = \theta'$.

Moreover, the length of the reflected *photon*, for the Observer, according to (17) is

$$\lambda' = \lambda + \Delta\lambda = \lambda(1+\beta) \tag{52}$$

where $\Delta\lambda = w_A T'$ and where $w_A = w\cos\theta$ is the component of the electron speed along the direction of the Observer A and T' (=1/ν') is, for A, the *photon* transit time, so we get

$$\lambda' - \lambda(\cong \Delta\lambda) = wT'\cos\theta. \tag{53}$$

Now the CoM along **w** is $(\gamma c/T')\cos\theta + (\gamma c/T')\cos\theta = m_e w$ giving

$$wT' = (2\gamma c\cos\theta)/m_e \tag{54}$$

and plugging this value into (53) we get

$$\lambda' - \lambda(\cong \Delta\lambda) = 2\gamma c\cos^2\theta/m_e = 2h\cos^2\theta/cm_e. \tag{55}$$

Now, $2\theta + \varphi = \pi, \Rightarrow \theta = (\pi - \varphi)/2$, hence $\cos\theta = \sin\varphi/2$ and therefore

$$\Delta\lambda = 2h\sin^2(\varphi/2)/cm_e \tag{56}$$

and since $2\sin^2(\varphi/2) = (1-\cos\varphi)$, *we get the Compton equation*:

$$\Delta\lambda = \lambda' - \lambda = h(1-\cos\varphi)/m_e c, \tag{57}$$

which cannot be obtained through the relativistic Doppler effect equation which, as for a source receding from the Observer, is $\lambda' = \lambda(1-\beta^2)^{1/2}/(1-\beta)$.

φ: angle between the direction of the incident ***photon*** and the scattered one (λ')
θ: angle between the direction of the incident ***photon*** and the recoiled electron
θ': (= $\pi - \varphi - \theta$) : it is shown that $\theta' = \theta$.

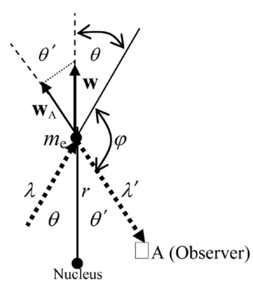

Figure A1. Compton effect.

Appendix B

Regarding the Conservation of Energy (CoE), $E = U + K = 0$, leading to $U = -\frac{1}{2}u^2$ the term K is the unitary (per unit of mass) kinetic energy of a massive particle, hence as for the light (having total energy, see (34), $E = K_c + K_i = \frac{1}{2}mc^2 + \frac{1}{2}mc^2$ with K_i its internal energy), we have to consider, to comply the CoE, its kinetic energy only, giving $U = -\frac{1}{2}c^2$, like any other massive particle. Anyhow, one can observe that the internal energy of light ($K_i = \frac{1}{2}mc^2$) of *photons* going toward the infinity could be lost, but this is not the case: indeed, we have seen on §6 (see also **Figure 4(a)**) that the frequency of a *photon* is constant along its path, and since, see (34), $K_i = \frac{1}{2}mc^2 = \frac{1}{2}\gamma\nu c^2 = \frac{1}{2}\gamma\lambda^2\nu^3$, it turns out that toward the infinity, where $c_\infty \rightarrow 0$, we get $\lambda_\infty \rightarrow 0$, yielding $K_{i\infty} \rightarrow 0$ (In other words, the internal energy of light only depends on the length of their *photons*).