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On the Trigonometric Descriptions of Colors

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Abstract

An attempt is presented for the description of the spectral colors using the standard trigonometric tools in order to extract more information about photons. We have arranged the spectral colors on an arc of the circle with the radius R = 1 and the central angle $\theta = \pi/3$ when we have defined $\cos(\theta) = \lambda_{380}/\lambda_{760} = 0.5$. Several trigonometric operations were applied in order to find the gravity centers for the scotopic, photopic, and mesopic visions. The concept of the center of gravity of colors introduced Isaac Newton. We have postulated properties of the long-lived photons with the new interpretation of the Hubble (Zwicky-Nernst) constant $H_0 = 2.748\ldots * 10^{-18}$ kg kg^{-1} s^{-1}, the specific mass evaporation rate (SMER) of gravitons from the source mass. The stability of international prototypes of kilogram has been regularly checked. We predict that those standard kilograms due to the evaporation of gravitons lost 8.67 μg kg^{-1} century^{-1}. The energy of long-lived photons was trigonometrically decomposed into three parts that could be experimentally tested: longitudinal energy, transverse energy and energy of evaporated gravitons. We tested the properties of the long-lived photons with the experimental data published for the best available standard candles: supernovae Type Ia. There was found a surprising match of those experimental data with the model of the long-lived photons. Finally, we have proposed a possible decomposition of the big G (Newtonian gravitational constant) and the small kappa κ (Einsteinian gravitational constant) in order to get a new insight into the mysterious gravitational force and/or the curvature concept.

Keywords: spectral colors on an arc, trigonometrical tools, gravity centers of visions, specific mass evaporation rate (SMER), stability of the Urkilogram, long-lived photons, longitudinal energy, transverse energy, evaporation of gravitons, decomposition of the big G, decomposition of the small κ.

1. Introduction

The mathematical description of colors and the color ordering stay in the focus of researchers for centuries. There were published many valuable monographs, e.g. Isaac Newton in 1730, Johann Wolfgang Goethe in 1810, W.W. Abney in 1913, Vasco Ronchi in 1970, A.I. Sabra in 1981, Robert A. Krone in 1999, Klaus Hentschel in 2003, Rolf G. Kuehni in 2003, John A. Medeiros in 2006, Rolf G. Kuehni and A. Schwarz in 2008 (the very inspirative monograph), B. Stabell and U. Stabel in 2009, A. Mark Smith in 2015.

The first system of color ordering was the qualitative linear order positioned on the horizontal axis by Aristoteles. Marcilio Ficino in 1480 and Girolamo Cardano (very well known for his calculations with imaginary numbers) organized colors on the vertical axis with the first (pseudo) quantitative brightness of colors in 1563. The next innovation proposed Robert Fludd around 1630 with the circular form of the modified Aristotelian scale of simple colors. The breakthrough brought Isaac Newton with his invention of the semi-quantitative color wheel describing the prismatic spectrum in 1702.

The next important stimulus was the quantification of the wavelength scale of the spectrum by William Hyde Wollaston in 1802, and Joseph Fraunhofer in 1812. Hermann Günther Grassmann made the Newtonian color wheel more quantitative by adding the Fraunhofer lines into the wheel in 1853. Grassmann was working with colors as with vectors in order to predict the results of their additive mixing. Hermann Scheffler modified the color wheel into a spiral by inserting frequencies of the spectral light in 1883.

The search for the key to unlock the secret code of these strange Frauhofer lines in the solar spectrum attracted several researchers in the 19th century. A very original step made Johann Jakob Balmer in 1885 and 1897 when he used some trigonometric tools to derive his important formula later used by many researchers.

The next big breaktrough came with Planck (1900) and Einstein (1905) with their formula $h\nu = mc^2$ describing the energy of photon particles.

The main reason of this contribution is to revisit some forgotten concepts found during the light decomposition using a prism in the 17th and 18th centuries and to use standard trigonometric tools in order to extract more information about photon properties. We will propose to decompose the Planck - Einstein formula using several trigonometric tools in order to extract more information about photons. These newly predicted photon properties can be tested by instrumental techniques available to our generation and could bring to us a new glimpse into the realm of photons.

2. The Prismatic Rainbow – "Iris Trigonia"

The seventeenth century was the century in which the rainbow started to reveal its secret to several researchers in their laboratories. These scholars decomposed the white light using the prism and observed the prismatic rainbow called as "Iris Trigonia". Iris, in the Greece mythology the goddess of rainbow, inspired those scholars who slowly started to understand this phenomenom.

E.g., Marci (1648) in his forgotten book "Thaumantias liber de arcu coelesti …" proposed that light passing the prism is compressed in the longitudinal direction and expanded in the transverse direction. This optical work of J.M. Marci was evaluated by Margaret D. Garber in 2005. The biography of J.M. Marci can be found in the book of Svobodný et al. (1998).

Boyle (1664) in his book "Experiments and Considerations touching Colours" speculated that light particles in the prism change their speed in the longitudinal and transverse directions. Robet Hooke (1665) speculated that the vibration of the light wave might cause the sense of colors. Isaac Newton in his "Optics" made many predictions for the future research. In one of his proposals he assumed that the vibration of light particles in the retina might cause the sense with various colors.

Many researchers described light particles as messengers with two properties – light energy and heat energy. E.g. Westfeld (1767) speculated that the retina could be stimulated by heat bringing with the light particles and the following increase in temperature might start the sense of colors. Johann Gottfried Voigt (1796) considered that light is a combination of light matter and caloric matter (two substances that appear on the top of Lavoisier´s table of elements).

It is possible to postulate an equation that could describe these qualitative arguments. We can mathematically describe two speeds of light particles passing through the prism by the proposal of Matzka (1850) that was rediscovered by Jiří Stávek in 2013. In this case we will postulate the new complex number – the Marci-Matzka complex number ¢ (read ¢ as cent):

$$¢ = \frac{c}{n} + i\, c \sqrt{1 - \frac{1}{n^2}} \tag{1}$$

where the modulus |¢| has the size of the light speed constant c = 299 792 458 ms^{-1} and n is the index of refraction of the prism. We can experimentally test the norm of this complex number multiplied by the mass of the photon m (in this case there is no loss of photon mass by the attrition or no growth of photon mass in the prism):

$$E = m\,¢^2 = m\frac{c^2}{n^2} + m\,c^2\left(1 - \frac{1}{n^2}\right) \tag{2}$$

The first member of this expression – the longitudinal energy is visible during the photoelectric effect and was very well tested and confirmed. The second part of this expression – the transverse vibration of photons – can be tested quantitatively as heat – the increased vibrations of the molecules used in these experiments. This second effect is known qualitatively but was not tested quantitatively. E.g., Arnošt Reiser et al. (1996) found that some molecules served as local heaters after their activation by light beam absorption and started to promote the following chemical reactions.

The wave theory of heat was intensively studied in the period 1800 – 1850 as we can read in the great contributions of Brush (1970, 1986). Experiments on radiant heat by William Herschel, John Leslie, Macedonio Melloni, André Marie Ampère, and others showed that heat has most if not all of the properties of light: reflection, refraction, diffraction, polarization, interference, etc. This led to a belief that heat and light are essentially manifestions of the same physical agent.

Equation 2 can be tested for the scotopic, photopic and mesopic visions. As the index of refraction we can apply the value n = 1.337 for the vitreous humor. For the case of the scotopic vision the very well known Purkinje effect might be caused by the longitudinal photon energy (Jan Evangelista Purkyně discovered the "Purkinje effect" in 1819). The photopic vision might be caused by the transverse photon energy as was anticipated long time ago by several researchers. The mesopic vision is influenced by both mechanisms.

3. Trigonometric Description of Colors – the Duplicity Theory

The visible spectrum for a typical health human eye lays in the wavelength range from 380 nm to 760 nm. The wavelength boundaries slightly depend on the individual human eye and on the optical conditions during these vision experiments. The human vision is very complicated multi-stage event. Our modern duplicity theory of vision is based on the experimental work of many researchers. E.g., Max Schultze in 1866 discovered rods and cones in the retina, Franz Boll in 1876 discovered rhodopsin as a visual photopigment. The history of the development of the duplicity theory surveyed B. Stabel and U. Stabel in 2009.

We can arrange colors on the circle with the radius R = 1 as an arc with the central angle $\theta = \pi/3$ if we will define $\cos(\theta) = \lambda_{380}/\lambda_{760} = 0.5$. This color arc ("the color sextant") together with used trigonometric functions is depicted in Figure 1.

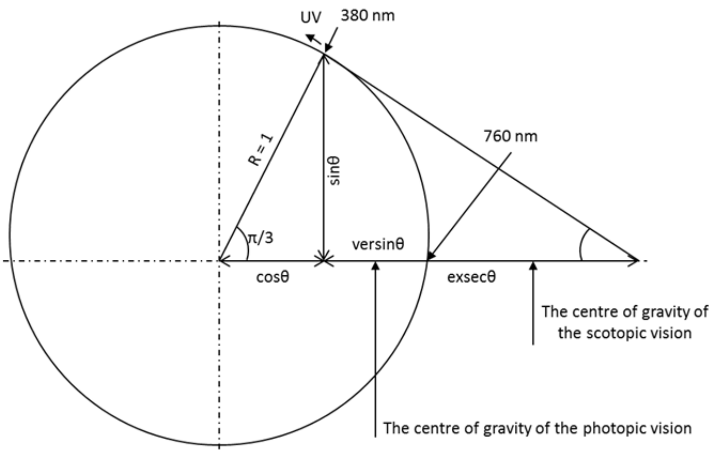

Figure 1. The "color sextant" of the visible light between 380 nm n mand 760 nm and some trigonometric functions for the determination of the centre of gravity of colors

From these relatively simple trigonometric functions we propose to formulate three Aristotelian horizontal linear color scales that describe the gravity centers of the scotopic, photopic and mesopic visions. Isaac Newton introduced in his color wheel the concept of the gravity center of colors. This topic is very well described by Briggs (2010) on his website. We will try to use this concept for the case of the trigonometric description of colors.

The scotopic vision will be modelled with the function exsec (θ) that describes the energy of individual colors where ν stands for the frequency of that color:

$$ex\sec(\theta) = \sec(\theta) - 1 = \frac{1}{\cos(\theta)} - 1 = \frac{\nu}{\nu_{760}} - 1 \tag{3}$$

The gravity center of the exsecant (θ) = 0.5 can be identified with the wavelength 506.6667 nm. This is an interesting coicidence with the maximal rod sensitivity at 507 ± 7 nm for a typical human eye – the scotopic vision. The scotopic efficacy curve is officially assigned a value of unity at 507 nm by the Commision Internationale d´Eclariage (CIE). The quatitative data can be found in the Luminous Efficacy Tables.

The photopic vision can be modelled with the function versin (θ):

$$ver\sin(\theta) = 1 - \cos(\theta) = 1 - \frac{\nu_{760}}{\nu} \tag{4}$$

The gravity center of the versin (θ) = 0.25 can be identified with the wavelength 570 nm. It is known that the short-, medium-, and long-wavelength cone pigments add together to result in a psychophysical spectral sensitivity curve that peaks at 560 ± 10 nm. It is another interesting coincidence for the case of the photopic vision. In order to cover the whole color spectrum by the photopic vision the typical human retina contains about 2% of S-cones, 34% of M-cones and about 64% of L-cones. The relative number of S-, M-, and L-cones and their active surface area form together the quantitative response to individual colors.

The subjective impression of seeing has to be quantified for „normal"viewing conditions. In 1924, the Commision Internationale d´Eclairage (CIE) statistically determined with over one hundred observers the maximum photopic sensitivity under controlled conditions and defined the maximum at 555 nm. Since that time there have been numerous attempts to improve the standard photopic luminosity function to make it more representative of human vision. The great photographic chemist Edwin H. Land made an extensive research on the color vision influenced by the various illumination parameters in 1977.

The intermediate vision – the mesopic vision when both rods and cones are active in the vision process – is strongly influenced by the luminance in the range from 0.005 cd/m^2 to 5 cd/m^2. For the case of the mesopic vision we will use cos (θ) = λ/λ_{760} in order to get probability relationships for the photopic vision ($\cos^2\theta$) and ($\sin^2\theta$) for the scotopic vision.

We can model the effect of photons on the sense of the mesopic vision as:

$$E = h\nu\left(\cos^2\theta + \sin^2\theta\right) = h\nu\left\{\left(\frac{\lambda}{\lambda_{760}}\right)^2 + \left[1 - \left(\frac{\lambda}{\lambda_{760}}\right)^2\right]\right\} \tag{5}$$

The first part of this expression describes the probability of the photopic vision and the second part describes the probability of the scotopic vision. The center of gravity for $\cos^2\theta = \sin^2\theta = 0.5$ can be identified with the wavelength 537.401 nm. The experimentally determined maximum for the mesopic vision depends strongly on the luminance and varies in the range 537 ± 30 nm. The future experimental study will be needed in order to investigate these coincidencies in more details. The UV light has been effectively blocked and do not enter the retina but has to be used for this statistical description as well.

Figure 2 shows the construction of three very well-known Pythagorean trigonometric identities. The trigonometric functions $\tan^2\theta$ and $\cot an^2\theta$ on the vertical axis were inspired by the Cardano´ formulas for probabilities. Geralomo Cardano was among the first researchers in the study of the calculus of probabilities. Cardano formulated two ratios r/s and s/r where r represents the favourable outcomes and s stands for unfavorable outcomes – see Gorroochum in 2012.

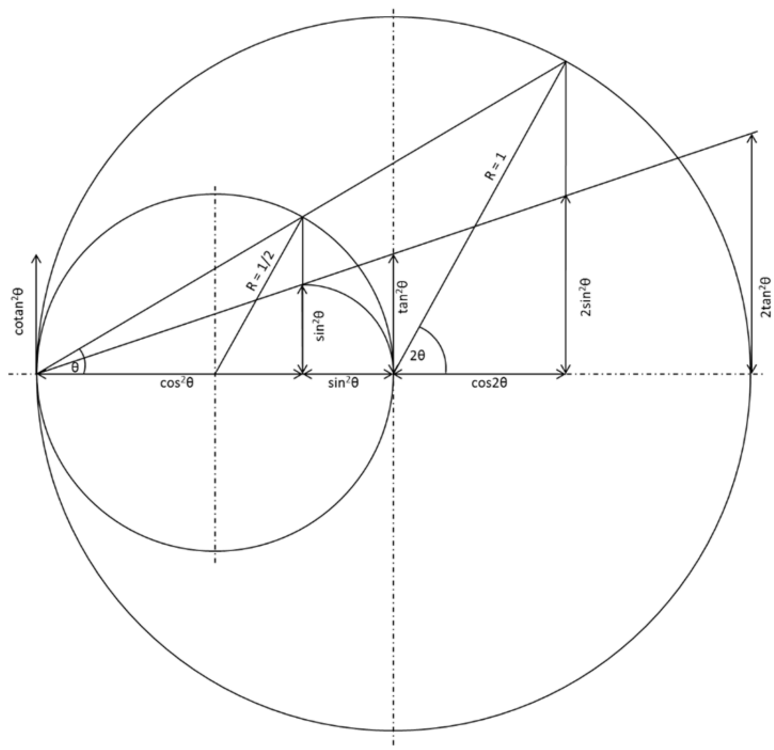

Figure 2. A trigonometric interpretation of $\tan^2\theta$ and $\mathrm{cotan}^2\theta$

The trigonometric functions on the vertical axis $\tan^2\theta$ and $\mathrm{cotan}^2\theta$ can be termed as Ficino-Cardano vertical orders of colors and are the measure of the scotopic – photopic vision probabilities for the colors in the mesoscopic vision range. Figure 3 depicts those Ficino-Cardano functions $\tan^2\theta$ and $\mathrm{cotan}^2\theta$ for the visible light.

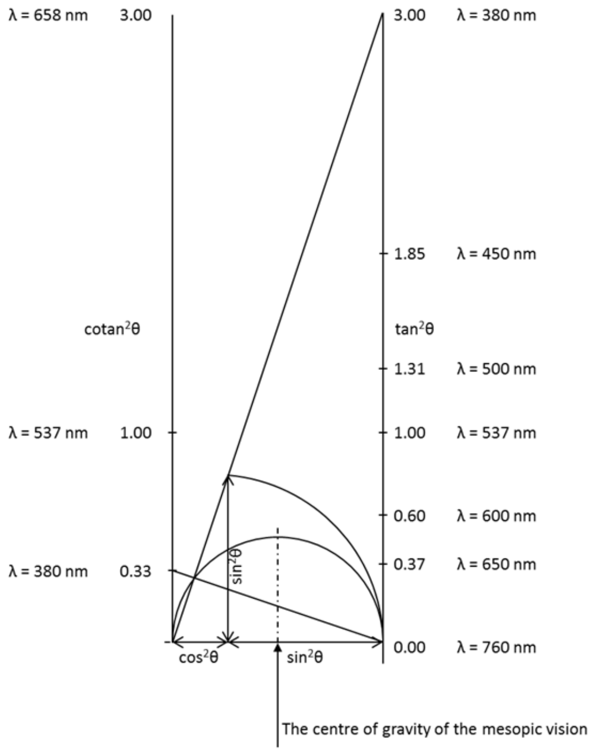

Figure 3. Ficino-Cardano functions $\tan^2\theta$ and $\cot an^2\theta$ describing the ratio of the probabilities of the scotopic–photopic visions

4. The Cosmological Transmutation of Colors

Christian Doppler (1842) predicted a color change of stars because of their relative motion to the observer. The observed redshifts and blueshifts in the analyzed spectra confirmed this Doppler prediction. However, during the next experimental investigation there were found bigger and bigger values of the observed redshifts. The dominant interpretation uses the characteristic Hubble constant with the dimension $kms^{-1}Mpc^{-1}$ describing the elasticity of the spacetime. There is one alternative concept proposed by Fritz Zwicky in 1929 and Walther Nernst in 1935. This model interprets the Hubble constant as a decay constant with the dimension s^{-1}. Nernst called the Hubbble constant as a quantum decay constant (Quantenzerfallskonstante). The development of this model slowly continued in stages through several generations. Marmet (2014) surveyed 59 interpretations of the cosmological redshift and his review might be a good starting base to this field of research.

In our trigonometric description of the cosmological transmutation of colors we will define several postulates:

(1) Hubble (Zwicky-Nernst) constant $H_0 = 2.748\ldots * 10^{-18}$ kg kg^{-1} s^{-1}, the specific mass evaporation rate of gravitons from the mass (SMER – in the Slovak language – “direction”), the numerical value will be derived later.

(2) Dependence of the photon wavelength, frequency, mass and complex longitudinal and transverse speed, and the average longitudinal speed on their life time.

(3) Matzka – Zwicky complex number describing the complex speed of the long-lived light.

(4) The cosmological hue angle $\cos(-\theta) = 1/(z+1)$ – see Figure 4.

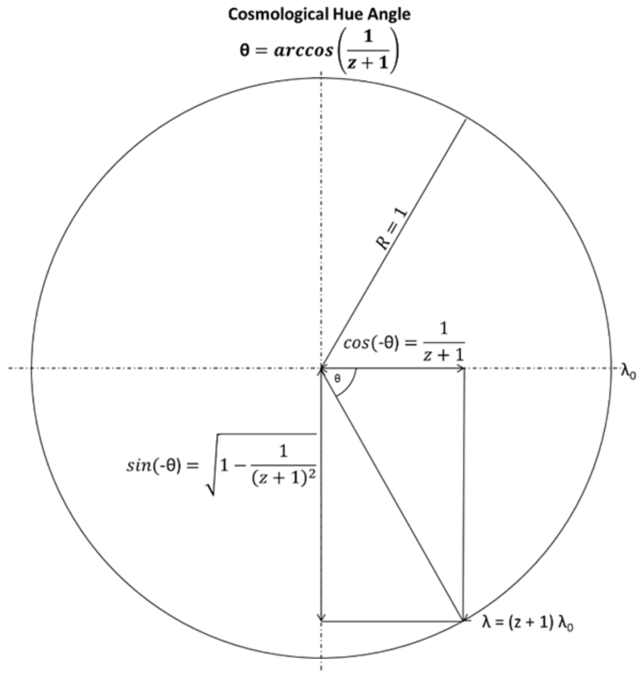

Figure 4. The cosmological hue angle θ = arccos [1/(z+1)] describing the cosmological transmutation of colors

The photon parameters are postulated as:

$$\frac{m_1}{m_0} = \frac{\lambda_0}{\lambda_1} = \frac{\nu_1}{\nu_0} = \frac{V}{c} = e^{-H_0\, t} = \frac{1}{z+1} \tag{6}$$

Parameters with the index 0 are at the source, parameters with the index 1 are at an observer, photon mass m, photon wavelength λ, photon frequency ν, V is the longitudinal photon speed at the observer, c is the light speed at the source, t is time for the photon flight and z is the redshift.

The longitudinal photon speed exponentially decreases and thefore the average longitudinal speed V_{av} can be calculated as:

$$V_{av} = \frac{c}{(z+1)^{1/e}} \tag{7}$$

Matzka – Zwicky complex number č (read "č" as cheers!) describes the longitudinal and transverse photon speed:

$$č = \frac{c}{z+1} - i\, c \sqrt{1 - \frac{1}{(z+1)^2}} \tag{8}$$

The first hypothesis of the varying-speed of-light was proposed by Peter Wold in 1935. Since that time this hypothesis was used several times in later works. The big problem of this hypothesis is the constancy of the Rydberg constant, the fine structure constant and other constants where the value of the light speed constant c = 299 792 458 ms^{-1} has to be inserted. In our model we can insert in those constants the modulus of Matzka – Zwicky complex number |č| = 299 792 458 ms^{-1}.

The trigonometric decomposition of the expression $E = m_0c^2$ for the long-lived photon is depicted on Figure 5.

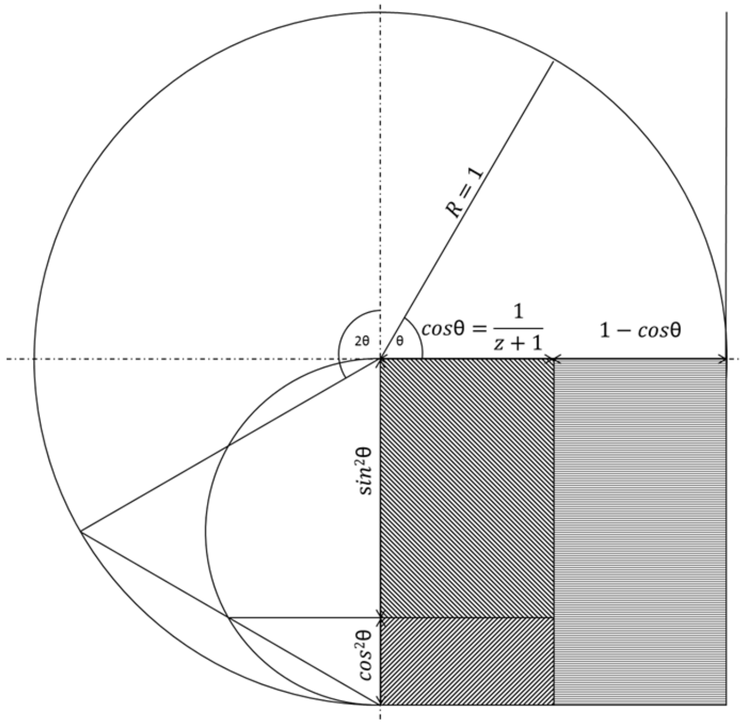

Figure 5. Trigonometric decomposition of the energy of the long-lived photon into the longitudinal energy, transverse energy, and graviton energy

This expression is composed from three members: the longitudinal energy and the transverse energy of the long-lived light and the third member stands for the graviton energy emitting from the long-lived light during its flight to an observer:

$$E = m_0 c^2 \left[\cos^3\theta + \cos\theta \sin^2\theta + (1 - \cos\theta)\right] =$$
$$= m_0 c^2 \left\{ \left[\frac{1}{(z+1)^3}\right] + \left[\frac{1}{(z+1)}\left(1 - \frac{1}{(z+1)^2}\right)\right] + \left[1 - \frac{1}{(z+1)}\right] \right\} \tag{9}$$

This trigonometric model of the long-lived light can be tested using the experimental data from the Hubble telescope:

(1) The longitudinal speed V = c/(z+1) – see data for the stretched temporal evolution of SNe Ia spectra: Leibundgut et al. in 1996, Goldhaber et al. in 1996 and 2001, Foley et al. in 2005, and Blondin et al. in 2008.

(2) The photoelectric effect of the long-lived light: in this experiment the longitudinal energy dependence on the redshift should be found with the exponent n = 3. The experimental data on the Tolman surface brightness test found the value n = 3.0 ± 0.4. For data see Lori M. Lubin and Alan Sandage (2001), Alan Sandage (2009) and Wikipedia (2016).

(3) Heat effect of the long-lived light – the transverse energy: the experimental data are not available.

(4) Specific mass evaporation rate (SMER – in the Slovak language „direction“) – graviton evaporation from the long-lived photons – we should focus our attention on the value of the Hubble (Zwicky – Nernst) constant with the dimension kg kg^{-1} s^{-1} and to compare this value with the mass evaporation of the Urkilogram.

Figure 6 summarizes the dependence of these three parameters on the redshift of those photons.

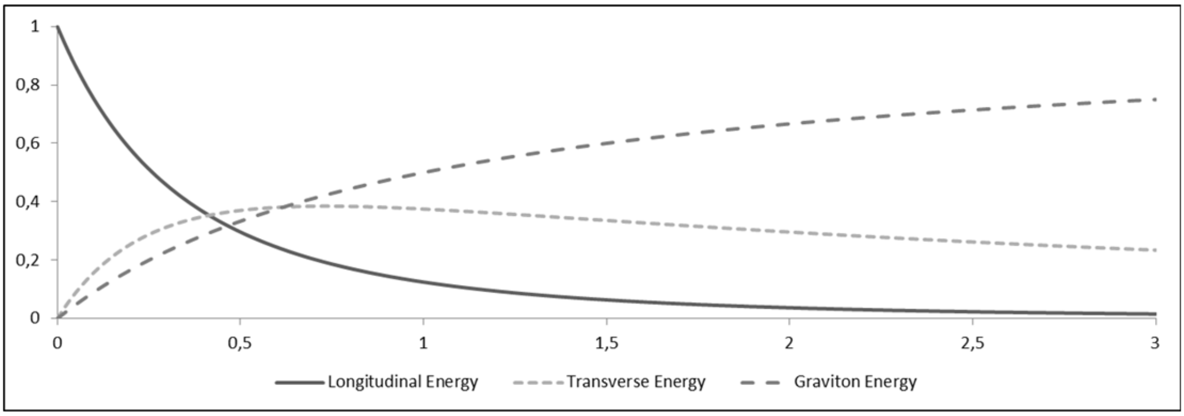

Figure 6. The predicted behavior of the long-lived photons on their redshift

We can test this long-lived light model using the experimental data published for the standard candles Supernova Type Ia. Firstly, we have to find the relation between the geometrical distance d of the measured supernova Type Ia and its luminosity distance d_L from the measurement of the longitudinal energy of long-lived photons:

$$E = h\frac{\nu_0}{z+1} = \frac{m_0 c^2}{(z+1)^3} \tag{10}$$

From this relation we find that the geometrical distance d = $d_L/(z+1)$. Then, we can express the luminosity distance from the postulates:

$$\ln(z+1) = H_0 t = H_0 \frac{d}{V_{AV}} = H_0 \frac{d_L}{(z+1)} \frac{(z+1)^{1/e}}{c} = \\ = \frac{H_0}{c} d_L (z+1)^{1/e-1} \tag{11}$$

$$d_L = \left[\frac{c}{H_0}(z+1)^{1-1/e} \ln(z+1)\right] \tag{12}$$

The Union2 Compilation (Amanullah et al., 2010) can be very well fitted with luminosity distance inserted into the standard formula for the supernova Type Ia:

$$\mathrm{m} - M = 5\log_{10}\left[\frac{d_L}{Mpc}\right] + 25 \tag{13}$$

$$\mathrm{m} - M = 5\log_{10}\left[\frac{c}{H_0}(z+1)^{1-1/e} \ln(z+1)\right] + 25 \tag{14}$$

where m is the apparent magnitude of the observed supernova, M is the absolute bolometric magnitude for the supernova Type Ia, c is the light speed, H_0 is the Hubble (Zwicky-Nernst) constant with the dimension kg kg^{-1} s^{-1} and z is the observed redshift, 25 enters the expression because the luminosity distance was expressed in Mpc.

The volumetric SN Type Ia rate has been recently studied in details using the Hubble telescope– see the data in Rodney et al. (2014) and Graur et al. (2014) with the maximum of the observed number of supernovae Type Ia in the spherical volume shell at around the redshift z = 1.60 ± 0.10. With our model we have found the maximum spherical volume shell at the redshift z = 1.59:

$$V_{eff} = V_2 - V_1 = \frac{4}{3}\pi \frac{c^3}{H_0^3}\left[\frac{(\ln(z_2+1))^3}{(z_2+1)^{3/e}} - \frac{(\ln(z_1+1))^3}{(z_1+1)^{3/e}}\right] \tag{15}$$

where V_{eff} is the spherical volume shell between the redshift z_2 and z_1, c is the light speed, H_0 is the Hubble (Zwicky-Nernst) constant with the dimension kg kg^{-1} s^{-1} and z_1 and z_2 are two redshifts for the spherical volume shell calculation.

5. What is the Internal Structure of the Big G and the Small Kappa κ?

In order to penetrate more deeply into the structure of the Newtonian big G and the Einsteinian constant small kappa κ we should try to decompose the big G into several pieces that might bring to us more information about the mysterious gravitational force and/or the curvature concept.

We should fulfill four conditions:

(1) Big G should contain the Hubble (Zwicky-Nernst) constant with the dimension kg kg^{-1} s^{-1} describing the specific mass evaporation rate (SMER) of gravitons from the source mass – the messengers of the gravitational force.

(2) Big G should be composed from the square of the longitudinal speed of gravitons $[c/(z+1)]^2$ because the product $\Sigma m_g*[c/(z+1)]^2$ describes the longitudinal energy of gravitons. This member $[c/(z+1)]^2$ might explain the great success of the predictions of the Einsteinian curvature theory using his constant small kappa $\kappa = 8\pi G/c^2$ (see Wikipedia for two possible writings of the kappa with c^2 or c^4). This clever definition of the constant kappa eliminated the square of the longitudinal speed of gravitons $[c/(z+1)]^2$ from the big G. Since Einstein´s constant κ had been evaluated by a calculation based on a time-independent metric, this by no mean requires that G and c must be constant themselves, but only their ratio G/c^2 must be the absolute constant.

(3) Big G should contain the Planck constant h to create a bridge between the microworld and the macroworld.

(4) The remaining member of the big G should match the dimension and the size the big G. As the best candidate we have found the size of the classical electron diameter $d_e = 2\ r_e = 5.63588*10^{-15}$ m.

$$G = \frac{d_e^3}{h}\left(\frac{c}{z+1}\right)^2 \frac{\sum m_{graviton}}{M_S T} \tag{16}$$

From the known constants G, d_e, h, c, for z = 0, we will get the value of the Hubble (Zwicky-Nernst) constant $2.74856*10^{-18}$ kg kg^{-1} s^{-1} (or $H_0 = 84.8116$ km s^{-1} Mpc^{-1}).

This value H_0 is higher than the recommended value from the astrophysical measurements (H_0 between 65 – 70 km s^{-1} Mpc^{-1}). The complexity of the experimental research on the Hubble constant can be found on the great web site of Huchra (2008). We should keep in mind that we get the deceleration parameter a_c in the form:

$$a_c = \frac{c\ H_0}{(z+1)} = \frac{c}{(z+1)} H_0 \tag{17}$$

We have two choices for the calculation of the value H_0. We can use for those calculations the modulus of the light speed |c| or the longitudinal light speed c/(z+1). The distance of the redshifted objects plays a very important role, too.

We might approach this Hubble (Zwicky-Nernst) constant from some other field of the experimental research. The stability of international prototypes of kilogram has been regularly checked. Girard (1994) analyzed the stability of mass of those standard kilograms during the last century and his data can be interpreted in such a way that in the average one kilogram lost during one century about 30 ± 30 μg kg^{-1} $century^{-1}$. In our concept the Hubble (Zwicky-Nernst) constant $2.74856*10^{-18}$ kg kg^{-1} s^{-1} describing the evaporation of gravitons we predict that the standard kilogram should evaporate gravitons with the rate 8.67 μg kg^{-1} $century^{-1}$. In the recent time several researchers in this field continue to develop more sensitive instruments for the better determination of the stability of the international prototypes of kilograms.

Based on the known constants G, d_e, h, c, for z = 0, we can define the graviton flux $\Phi_{e,M}$ with the dimension W kg^{-1} as:

$$\Theta_{e,M} = \left(\frac{c}{z+1}\right)^2 \frac{\sum m_{graviton}}{M_S T} = 0.247...\ W\, kg^{-1} \tag{18}$$

(Comment: We can compare the Solar Luminosity $L_S = 3.846*10^{26}$ W with the Solar Gravitality $G_S = 4.914*10^{29}$ W).

6. Conclusions

(1) The spectral colors were arranged on the arc of the circle with the radius R = 1 and the central angle θ = π/3 when we have defined cos (θ) = $\lambda_{380}/\lambda_{760}$ = 0.5.

(2) Trigonometric functions were used to find the gravity centers for the scotopic, photopic, and mesopic visions. This approach might bring new information about the mechanisms of those scotopic, photopic and mesopic visions.

(3) The properties of the long-lived photons were postulated with the new interpretation of the Hubble (Zwicky-Nernst) constant $H_0 = 2.748\ldots * 10^{-18}$ kg kg^{-1} s^{-1}, the specific mass evaporation rate of gravitons from the source mass (SMER).

(4) It was predicted that international standard kilograms due to the evaporation of gravitons lost 8.67 µg kg^{-1} $century^{-1}$.

(5) The energy of the long-lived photons was trigonometrically decomposed into tree contributions that could be experimentally tested: the longitudinal energy, the transverse energy, and the energy of evaporated gravitons.

(6) The postulates of the long-lived photons were tested with the actual data sets found for the standard candles – supernova Type Ia. The match of predictions with the experimental data was very good.

(7) It was proposed a possible decomposition of the big G (Newtonian gravitational constant) and the small kappa κ (Einsteinian gravitational constant) in order to get a new insight into the mysterious gravitational force and/or the curvature concept.

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