UNIVERSAL REDSHIFT – DISTANCE RELATION, AND ENERGY AND EJECTED MASS OF AVERAGE SUPERNOVA OF TYPE Ia

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ABSTRACT

Paper presents application of Universal redshift-distance relation, r = {c/H}ln(1+Z) to round estimation of properties of average Supernova of type Ia (here r is distance to extragalactic object, c ≈ 299792 km/s is speed of light, H ≈ 72 km/s per Mps is Hubble constant, 1 Mpc = 3.0857×10^{19} km, Z = $\lambda/\lambda_o - 1$ is redshift, λ is observed wavelength of light from distant object and λ_o is wavelength of light emitted by object). As estimated from Permutter et al's (1999) data, average Supernova of type Ia is specified by absolute peak luminosity ~3.26 billions of Suns (1.25×10^{36} W, with variability by ~ 0.4 ÷ 2 times), and absolute emitted energy E ~ 3.24×10^{42} J, equivalent to explosion of ~ $1000\times E/c^2 = 3.6\times10^{28}$ kg of nuclear fuel (= 1.8 % of Solar mass).

TIRED LIGHT UNIVERSE

In accordance with theory of Tired Light, there is no expansion of Universe, and Universal red shift is result of some unknown effect (e.g., interaction of light with free electrons of intergalactic plasma: see Brynjolfsson, 2005; Pivovarov, 2015). If we see doubling of wavelength of light, coming from galaxy G1, located at distance r = a from the Earth, inhabitants of galaxy G1 should observe similar doubling of wavelength for light coming from galaxy G2, located at distance r = 2a from the Earth and at distance r = a from G1. Consequently, we should observe quadrupled wavelength of light from galaxy G2, and, in general case, $\lambda_{observed}/\lambda_{emitted} = 2^{r/a}$. As may be seen, immediately from Copernicus principle, one may obtain Stewart-Brown law of Universal red shift (Stewart, 1931; Browne, 1962):

$$Z + 1 = \lambda/\lambda_o = \exp(r/R_U) \quad (1)$$

Here Z is red shift, λ is observed wavelength of light from extragalactic object, λ_o is initially emitted wave length, r is distance to extragalactic object, R_U is Brown's "radius of Universe":

$$R_U = c/H \approx 4164 \text{ Mpc} \approx 1.285\times10^{23} \text{ km} \quad (2)$$

Here c = 299 792 km/s is speed of light, H = 72±8 km/s per Mps is Hubble constant (Freedman et al, 2001), Mps is megaparsec (1 Mps = 3.0857×10^{19} km).

At small distances, Stewart-Brown law coincides with limiting Hubble law:

$$Z = rH/c = r/R_U \quad (3)$$

Stewart-Brown law may be rewritten as:

$$Z + 1 = \exp(Ht) = \exp(t/t_U) \quad (4)$$

Here t = r/c is age of observed light, and t_U is "age of Universe":

$$t_U = 1/H = 13.58 \text{ billions of years} \quad (5)$$

Note here, that in accordance with theory of Tire Light, Universe is eternal and infinite, whereas "age of Universe" and "radius of Universe" are just familiar names for exponential factors.

In accordance with Stewart-Brown law, distance to extragalactic object may be calculated from measured red shift:

$$r = R_U \times \ln(Z+1) \quad (6)$$

BIG BANG UNIVERSE WITHOUT ACCELERATION

In accordance with Big Bang theory, the Universe expands, and Universal red shift for extragalactic object is defined by "relativistic Doppler effect":

$$Z + 1 = \{(1 + v/c)/(1 - v/c)\}^{0.5} \quad (7)$$

Here v is "recession velocity" of extragalactic object. Eq (7) may be rewritten as:

$$v = c\{(Z + 1)^2 - 1\}/\{(Z + 1)^2 + 1\} \quad (8)$$

Assuming no acceleration, present distance to extragalactic object is then defined by:

$$r_{present} = v \times t_U = R_U \times \{(Z + 1)^2 - 1\}/\{(Z + 1)^2 + 1\} \quad (9)$$

Here, like in Eq. (5), $t_U = 1/H$ is age of Universe, but without inverted commas. In accordance with Big Bang theory (without acceleration), 1/H = 13.58 billions of years ago is, literally, date of "Big Bang".

However, we see in the sky the old times of Universe, and visible distance to object, r , also refers to past times. The light, that we see, was emitted $\Delta t = r/c$ seconds ago. Thus, apparent distance to the object is:

$$r = v \times \{t_U - r/c\} = 0.5R_U \times \{1 - 1/(Z + 1)^2\} \quad (10)$$

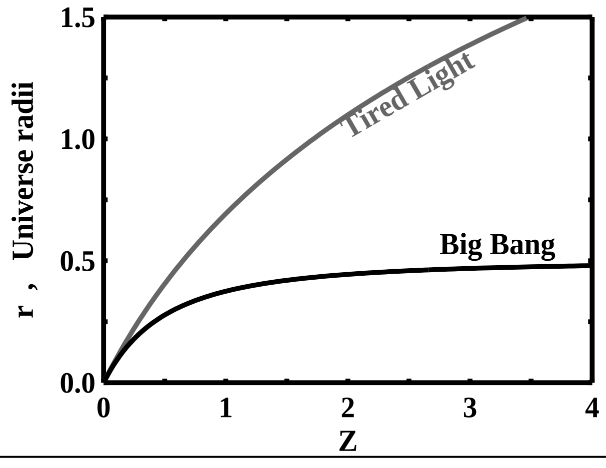


Fig. 1 Apparent distance to object, r (in Universe radii: 1 R_U = 4164 Mpc = 1.285×10^{23} km) versus measured redshift, Z. Black curve: Big Bang Universe with no acceleration (Eq. 10). Gray curve: Tired Light Universe (Eq. 6).

In **Fig. 1**, theoretical distance-redshift relations are visualized. As may be seen, observable Big Bang Universe with no acceleration is limited to $0.5R_U$, and there are no detectable objects above this distance, even in the radio diapason. Contrarily, Tired light Universe is infinite: observed objects with redshift $Z > \exp(1) - 1 \approx 1.7183$ are located at distances > R_U.

SOME ASTRONOMICAL CONSTANTS

From very old times, luminosity of distant object is measured in “apparent magnitudes”:

$$m = 2.5\times\log(L_{st}/L) + m_{st} \qquad (11)$$

Here L is measured luminosity of object in some arbitrary units, L_{st} is measured apparent luminosity of “standard star” with known magnitude m_{st}. Such method allows minimize the effects arising due to variability of equipment, state of atmosphere, altitude of object above horizon, altitude of telescope above sea level, ets. Magnitude of Vega is ~ + 0.03 (Wikipedia, 2017a), and apparent magnitude of object may be converted to apparent luminosity of object:

$$L/L_{Vega} = 10\text{^}\{-0.4(m - m_{Vega})\} \sim 10\text{^}\{-0.4m\} \qquad (12)$$

For instance, mean apparent luminosity of Sun (m_{Vega} = +0.03: Wikipedia 2017a; m_{Sun} = – 26.74: Wikipedia 2017b) is 51 billions of Vegas. In physical units, year-mean L_{Sun} is 1361 W/m^2 (Wikipedia 2017c) and L_{Vega} is 2.666×10^{-8} W/m^2 (as L_{Sun} divided by 51 billions). These values are extraterrestrial ones (i.e. observable with Hubble Space Telescope). Due to absorption and dispersion of light by the Earth’s atmosphere, terrestrial telescope catches at clear sky ~ 2/3 of total incoming light energy from the object (depending on altitude of object above horizon, state of atmosphere, etc). However, calibration with use of “standard star”, allows minimize this effect.

The absolute luminosity of the object is then defined by:

$$\Lambda = L\times4\pi r^2\times(1+Z) \qquad (13)$$

Here Λ is total light energy, emitted by object per second. From known distances (r_{Sun} = 1 au = 1.49598×10^8 km: Wikipedia 2017b); r_{Vega} = 7.68 pc (Wikipedia 2017a) = 2.37×10^{14} km), and neglecting red shifts (Z ~ 0), absolute luminosities of Sun and Vega from Eq. (13) are: Λ_{Sun} = 3.83×10^{26} W, and Λ_{Vega} = 1.88×10^{28} W = 49 Suns.

Table 1 Some astronomic constants.

Object	M (Apparent magnitude)	L (Apparent luminosity, extraterrestrial values)	r (Distance from the Earth)	Λ (Absolute luminosity)
Vega	+ 0.03[a]	2.666[b]$\times10^{-8}$ W/m^2	1.584×10^6 au = 2.370×10^{14} km = 7.68[a] pc = $1.844\times10^{-9}\times R_U$	1.88[c]$\times10^{28}$ W
Sun	– 26.74[d]	1361[e] W/m^2	1 au = 1.49598[f]$\times10^8$ km = 4.8481×10^{-6} pc = $1.1643\times10^{-15}\times R_U$	3.83[c]$\times10^{26}$ W

a Wikipedia (2017a) Vega. (m_{Vega} ranges from – 0.02 to + 0.07 with mean + 0.03)
b $L_{Vega} = L_{Sun}\times10\text{^}\{0.4\times(m_{Sun} - m_{Vega})\}$
c From Eq (13) with Z = 0.
d Wikipedia (2017b) Sun (m_{Sun} varies from – 26.71 (3 July) to – 26.78 (3 January))
e Wikipedia (2017c) Solar constant (L_{Sun} varies from ~1321 (3 July) to ~1412 (3 January) W/m^2)
f Wikipedia (2017d) Earth (distance between Sun and Earth varies from 147 095 000 (3 January) to 152 100 000 (3 July) km)

PROPERTIES OF AVERAGE "STANDART CANDEL"

As expected, Supernovae of type Ia are almost identical objects, and they may be used as "standard candles" for estimation of distances in Universe. In general case, dependence of apparent peak magnitude of Supernova of type Ia on distance is:

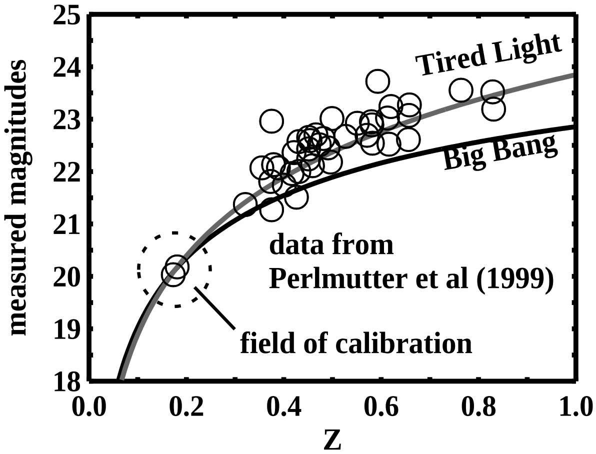
$$m \sim \text{const} + 2.5\times\log\{r^2\times(1+Z)\} \qquad (14)$$

Here "const" is fitting parameter, factor r^2 reflects decay of apparent luminosity with distance (number of photons per second and per unit area of telescope lens decreases with distance to object as ~ $1/r^2$), factor (1+Z) reflects energy loss of each counted photon (as 1/(1+Z)).

Taking distance to object, r, from Eqs (6) and (10), one may obtain redshift-magnitude relations for identical objects:

$$m \sim \text{const'} + 2.5\times\log[\{\ln(1+Z)\}^2\times(1+Z)] \qquad \text{(Tired Light)} \qquad (15)$$

$$m \sim \text{const''} + 2.5\times\log[0.25\times\{1-1/(1+Z)^2\}^2\times(1+Z)] \qquad \text{(Big Bang)} \qquad (16)$$



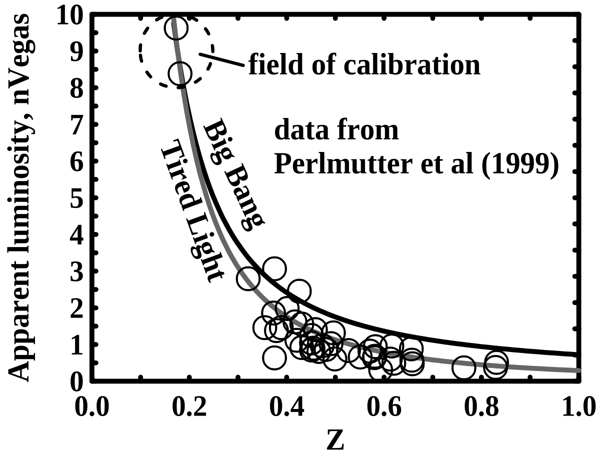


Fig. 2 Apparent peak magnitudes of distant Ia type Supernovae, as measured by Perlmutter et al (1999) with red or infrared filters (not specified). Curves, Eq (15, Tired Light) and Eq (16, Big Bang) were calibrated to peak magnitudes of two nearest Supernovae (see "field of calibration").

Fig. 3 Data and curves from Fig. 2, converted via Eq. (12) to scale of apparent luminosity (in nano-Vegas: 1 nVega = 2.666×10^{-17} W/m^2).

In **Fig 2**, peak magnitudes of distant Supernovae of type Ia are shown, as measured by Perlmutter et al (1999) with use of red (5617÷7197 Å) or infrared (7210÷8750 Å) filters (not specified). Solid curves were calculated with use of Eqs (15) and (16). Both curves were fitted to peak magnitudes of two nearest Supernovae (see "field of calibration"). As may be seen, Big Bang theory (Eq 15) significantly deviates from observations. It should be noted that, dew to redshift, no objects may be detected at Z > ~ 1.7 in visible diapason (~ 4000÷8000 Å). Nevertheless, method of "color magnitudes" is roundly applicable up to Z ~ 0.7 for red magnitudes, and up to Z ~ 1.2 for infrared magnitudes.

In **Fig. 3**, data and curves from **Fig. 2** are converted to scale of apparent luminosity via Eq. (12). As may be seen, apparent peak luminosities of distant Supernovae with redshifts Z = 0.4÷0.8 are ~ 2 times smaller than expected from Big Bang theory. Thus, apparent distances to distant Supernovae are ~ $2^{0.5}$ times larger than expected from Eq. (10). As deduced by Perlmutter (2012), deviation of Big Bang theory from reality is a direct evidence for accelerated expansion of Universe.

Fig. 4 shows 3 buses, started together. At "present time", all 3 buses have equal velocities (and thus equal Doppler redshifts). As may be seen, the bus, moving with constant deceleration (a<0), covers largest distance because of larger velocity at Big Start. Thus, contradiction between Big Bang theory and reality may be somehow reduced.

As may be seen in **Figs 2 and 3**, theory of Tired Light gives true magnitude-redshift, and thus, true distance-redshift relation (Eq. 6). With use of true redshift-distance relation (Eq. 6), one may estimate absolute peak luminosity of distant Ia type Supernova:

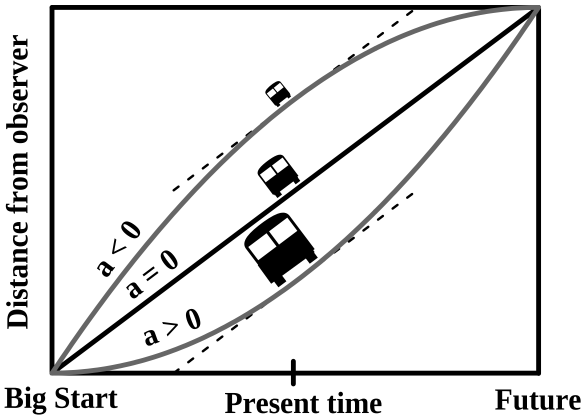


Fig. 4 Three buses starting together, and, in present time, moving with equal recession velocities (as defined by slope of time-distance curves).

$$\Lambda/\Lambda_{Sun} = 10^{-0.4(m - mSun)}\times(r/r_{Sun})^2(1+Z) =$$

$$= 10^{-0.4m}\times1.485\times10^{19}\times\{\ln(1+Z)\}^2(1+Z) \qquad (17)$$

Here Λ is absolute peak luminosity of distant object, $\Lambda_{Sun} = 3.828\times10^{26}$ W is absolute luminosity of Sun, m and r are magnitude and distance to object, m_{Sun} = -26.74 is apparent magnitude of the Sun, r_{Sun} = 1 au = 1.49598×10^8 km = $1.1643\times10^{-15}\times R_U$ is average distance to the Sun, constant factor 1.485×10^{19} is $10^{0.4mSun}\times(R_U/r_{Sun}\}^2$.

In **Fig. 5**, data from **Fig. 2** are converted to scale of absolute luminosity with use of Eq. (17). As may be seen, absolute peak luminosity of "standard candles", measured by Perlmutter et al (1999), ranges between 1.34 to 6.55 billions of Suns, with arithmetic mean 3.65 billions of Suns.

It should be noted that the peak magnitudes of Supernovae in **Fig. 2** from Perlmutter et al (1999) are given as measured, i. e., without correction on background emission. Contribution of background luminosity was measured by Perlmutter et al (1999) at 0.03÷0.21 magnitudes (i.e., 3÷18 %), plus 3 noisy measurements (background contribution 0.35, 0.42, and 0.61 magnitudes, or 28, 32 and 43 %). With background correction, arithmetic mean Perlmutter et al's (1999) "standard candle" peak luminosity is 3.26 billions of Suns (with range 1.23÷6.37 billions of Suns), or 1.25×10^{36} W.

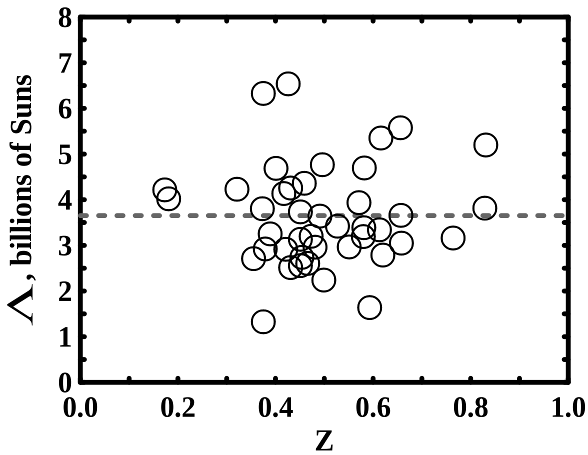


Fig. 5 Absolute peak luminosity of Supernovae of type Ia versus redshift. Data from **Fig. 2** (Perlmutter et al. 1999) converted with use of Eq.(17); 1 billion of Suns = 3.83×10^{35} W. Dashed line: arithmetic mean 3.65 billions of Suns.

Guessing duration of average Perlmutter et al's (1999) Supernova as d ~ 60 days = 5.184×10^6 seconds (see Pivovarov, 2017), total energy of explosion, E, may be estimated as ~ $\Lambda\times d/2$ = 97.8 billions of Solar days = 3.24×10^{42} J (with range $1.22\div6.33\times10^{42}$ J). From this value, mass defect of average Supernova, Δm, may be estimated as $E/c^2 = 3.6\times10^{25}$ kg. With commonly observed efficiency of nuclear fuel (≈ 0.1 mass %), total mass, ejected by average Supernova, M_{ej}, may be estimated as $\sim1000\times\Delta m = 3.6\times10^{28}$ kg = 1.8 % of Sun (Solar mass is ≈ 1.99×10^{30} kg) or 13.5 "Solar planetariums" (total mass of planets of Solar system is ≈ 2.67×10^{27} kg). As may be seen, mass loss is not fatal for central star, whereas small fraction of ejected mass may generate new planetary system.

The age of light from Perlmutter et al's (1999) Supernovae is ~ 2÷8 billions of years, which is enough for generation of planets and life. And may be, right now, inhabitants of these planets observe the birthday of Solar planetary system, with bright Oort cloud around.

It should be noted, that the previously published estimates of ejected masses are close to ~ 1.4 Solar masses (with range ~ 0.15÷14 Solar masses: see Pivovarov (2017) and references herein). May be, previous estimates are affected by enigmatic nature of emission from rarified hot plasma (see Pivovarov, 2016). For instance, spectra of Supernova of type Ia are always peaked at ~ 4000×(1+Z) Å, which is equivalent to "black body temperature" 7244 K. From the other hand, conversion of nuclear energy, ~ $0.001M_{ej}c^2$, into heat energy, ~ $M_{ej}v^2/2$, leads to huge heat movement with average initial heat velocity v ~ $(0.002c^2)^{0.5}$ = 13407 km/s, equivalent to initial "proton temperature" ~$m_pv^2/3k$ = 7.26 billions of K. Taking into account for Stefan-Boltzmann law of black body luminosity (L ~ αT^4), discrepancy by 2 orders seems to be insignificant.

Besides, it is possible that the direct light emission from ejected mass is simply undetectable, whereas observable light emission is just a light echo from interstellar medium, excited by gamma-spark: thanks to Compton's effect, interstellar medium is almost impermeable for gamma-emission. If so, total mass of interstellar medium, excited by gamma-spark, may be really comparable with Solar mass. For instance, 1 Solar mass (1.99×10^{30} kg), uniformly distributed within the sphere with radius 60 light days = 10389 au = 1.554×10^{12} km, gives density of interstellar medium 1.27×10^{-16} kg/m^3, which is close to density of Space above Saturn's orbit: ~ 1.34×10^{-16} kg/m^3 (Pivovarov, 2018), or ~ 3×10^{-16} kg/m^3 (Nieto et al 2005).

CONCLUDING REMARKS

Total energy of average Supernova of type Ia is ~ 3.24×10^{42} J, which is equivalent to nuclear explosion of 1.8 percents of Solar mass. Theory of Tired Light gives true distance-redshift relation. NO BIG BANG!!! UNIVERSE FOREVER!!!

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