SPECTRA AND ENERGY OF SUPERNOVAE OF TYPE Ia

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ABSTRACT

Absolute luminosities of distant Supernovae of type Ia were estimated with use of published spectra. Two subgroups of type Ia were distinguished: “overluminous” Supernovae with mean absolute peak luminosity ~ 9.82 milliards of Suns, and “normal” Supernovae with mean absolute peak luminosity ~ 2.11 milliards of Suns. Up to redshift Z = 1, theory of Tired Light is well consistent with observation. Thus, Universe is Eternal and Infinite.

INTRODUCTION

As has been obtained by Hubble (1929), light spectra from almost all extragalactic objects are shifted toward red side, and red shift of specific spectral lines is roundly proportional to distance r:

$$Z = \{\lambda_{meas} - \lambda_{emitted}\}/\lambda_{emitted} \sim \{H/c\}\times r \qquad (1)$$

Here Z is measured redshift, λ_{meas} is measured wavelength, and $\lambda_{emitted}$ wavelength emitted by extragalactic object, H = 72 km/s per Mps is Hubble constant (Freedman et al, 2001), Mps is megaparsec (1 Mps = 3.0857×10^{19} km), c is speed of light (299792.458 km/s), and r is distance to extragalactic object. However, Hubble law is not applicable at Z > 0.3.

In accordance with theory of Tired Light, were is no expansion of Universe, and distance to extragalactic object is defined by Stewart-Brown law (Stewart, 1931; Brown, 1962):

$$r = R_U\times\ln(1+Z) \qquad (2)$$

Here r is distance to object, $R_U = c/H = 4164$ Mpc = 1.285×10^{23} km is “radius of Universe”.

In previous study (Pivovarov, 2018a), Stewart-Brown law (Eq 2) was verified with use of peak color magnitudes of Supernova of type Ia, measured by Perlmutter (1999). Absolute peak luminosity of average supernova of type Ia was very roundly estimated at 3.26 billions of Suns (billion = milliard = 10^9; absolute luminosity of Sun = 3.828×10^{26} W). However, total emission from distant object, guessed with use of one color magnitude seems to be doubtful. So, let us consider direct spectral measurements.

SOLAR SPECTRUM

Fig. 1 shows extraterrestrial Solar spectrum from Johnson (1954). Integer sum of these data (plus zero count at ν = 0) is 1395 W/m^2 (=2 calories per cm^2 per minute, as reported by Johnson, 1954). This is a bit larger than modern value of Solar constant 1361 W/m^2 (Wikipedia, 2018a). However, there is no reason to suspect Global Cooling: Johnson’s (1954) extraterrestrial Solar spectrum was created via extrapolation of data from terrestrial telescopes, and deviation from modern value by 2.5 % is close to error ±2 %, estimated by Johnson (1954). Besides, because of elliptic shape of the Earth’s orbit, luminosity of Sun varies between ~1317 and ~1408 W/m^2, and Johnson’s (1954) result fall into this range.

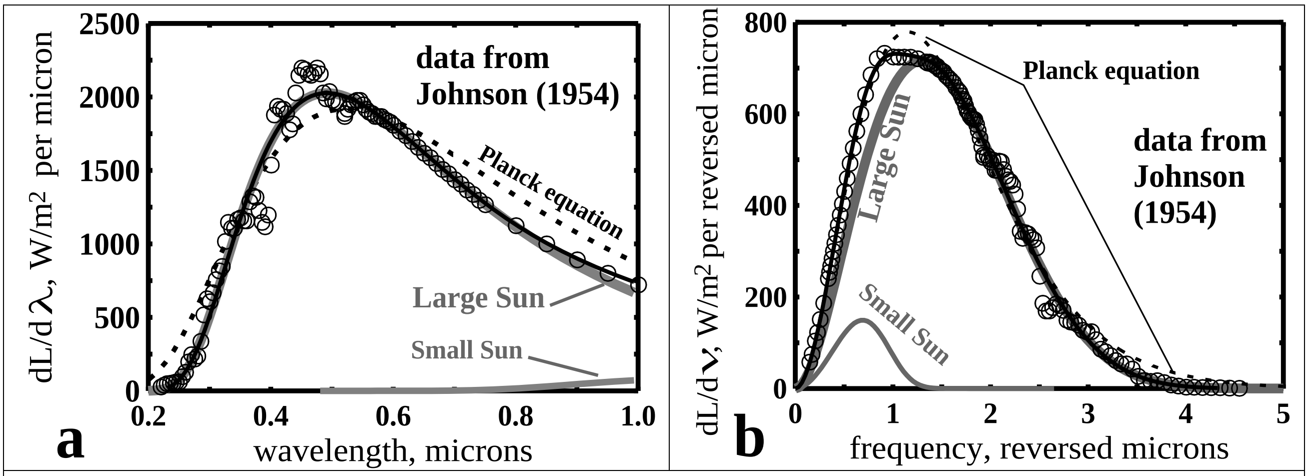

Fig. 1 Extraterrestrial spectrum of Sun on (a) wavelength (microns) and (b) frequency (reversed micron) scales. Data from Johnson (1954). Dashed curves: Planck equation (Eq. 3). Grey solid curves: Eq (7) with $A_1 = 2206$, $B_1 = 2.057$, $C_1 = 0.3236$ for "Large Sun" and $A_2 = 800.4$, $B_2 = 1.585$, $C_2 = 1.107$ for "Small Sun". Black solid curve: cumulative spectrum.

Solar spectrum may be roundly approximated by "black body" model, as given by Planck equation (see dashed curves):

$$dL/d\lambda, \text{ W/m}^2 \text{ per micron} = AB/[\lambda, \mu m]^5/(\exp(B/[\lambda, \mu m])-1) \qquad (3) \text{ or}$$

$$dL/d\nu, \text{ W/m}^2 \text{ per reversed micron} = AB[\nu, 1/\mu m]^3/(\exp(B[\nu, 1/\mu m])-1) \qquad (3a)$$

Here A=4159, B=2.604 are best fit parameters for Eq (3), and A = 3303 and B = 2.455 are best fit parameters for Eq. (3a).

Parameter B is defined by:

$$B = 10^6 \times hc/kT \qquad (4)$$

Here 10^6 is number of microns per meter, $h = 6.626176\times10^{-34}$ J×s is Planck constant, c = 299792458 m/s is speed of light, $k = 1.380662\times10^{-23}$ J/K is Boltzmann constant, T is absolute temperature:

$$T, K = 14388/B \qquad (5)$$

From Eq. (5), best-fit temperature of Solar photosphere may be estimated as T = 5525÷5861 K (5693 K on average). Integer to Planck equation is, exactly

$$L = (\pi^4/15)\times AB/B^4 = 6.4939394\ldots\times A/B^3 \qquad (6)$$

From Eq (6), Solar constant (1954) may be estimated as 1450÷1530 W/m^2 (error 4÷10 %). As may be seen, black body model (Eq. 3) is rather uncertain in application to the Solar spectrum.

Indeed, Solar light comes from photosphere, which is hot atmosphere of Sun. From gravity at Solar "surface", $g_S \approx 274$ N/kg, average molar weight, M ≈ 1.24 g/mol (H ~ 75 wt %, He ~ 25 wt %), and averaged "black body" temperature T ≈ 5693 K, thickness of photosphere may be estimated as ~ RT/gM ~ 8.314×5693/{274×1.24} ~ 139 km (truly, this layer contains ~ 100 – 100/e ≈ 63 % of total mass of photosphere, whereas doubled layer, ~ 278 km, contains ~ 100 – 100/e^2 ≈ 86 % of total mass, etc).

Solar light comes from all depths of photosphere, and thus, significant Raleigh scattering may be expected on blue side of spectrum:

$$dL/d\lambda\text{, W/m}^2\text{ per micron} \approx AB/[\lambda, \mu m]^5/(\exp(B/[\lambda, \mu m] - 1)/\exp[(C/[\lambda, \mu m])^4] \qquad (7)\text{ or}$$

$$dL/d\nu\text{, W/m}^2\text{ per reversed micron} \approx$$
$$\approx AB[\nu, 1/\mu m]^3/(\exp\{B[\nu, 1/\mu m] - 1)/\exp[(C[\nu, 1/\mu m])^4] \qquad (7a)$$

Term $1/\exp[(C/[\lambda, \mu m])^4]$ in Eq. (7) = term $1/\exp[(C[\nu, 1/\mu m])^4]$ in Eq (7a) is Raleigh scattering law, and C is additional adjusting parameter. Solar spectrum looks like a cumulative spectrum of double star, and solid curves in Fig 1 were calculated with A_1 = 2206, B_1 = 2.057, C_1 = 0.3236 for "Large Sun" and A_2 = 800.4, B_2 = 1.585, C_2 = 1.107 for "Small Sun". Numerical integration of this fit gives Solar constant 1390 W/m^2 which is close to integer of experimental data (1395 W/m^2). Taking into account for large features on blue side of spectrum (see Fig 1), multilayer model seems to be more applicable. However, double layer model of Solar photosphere is enough for estimation of Solar constant with error 5 W/m^2 (0.36 %).

Emission from "Small Sun" is 97 W/m^2, and this large feature of spectrum cannot be simply neglected. May be, infrared "Small Sun" is remainder of emission from the convective zone of Sun, almost completely absorbed by photosphere. Indeed, best-fit temperature of "Small Sun" is ~ 14388/B_2 = 9078 K. Taking into account for estimated "black body" temperature of Sun, about ~ 5693 K, and guessed temperature at the top of convective zone (= bottom of photosphere), ~ 9078 K, Sun is "white body", covered by photosphere, like a warm blanket.

Absolute luminosity of the object is defined by

$$\Lambda = L\times 4\pi r^2\times(1+Z) \qquad (8)$$

Here L is measured luminosity, π = 3.14159265…, r is distance to object, and Z is redshift.

Solar wind near the Earth is specified by density ~ 5×10^6 of proton-electron pairs per m^3 and particle velocity ~ 500 km/s. With mass of hydrogen atom (~ 1.67356×10^{-27} kg), mass flux is ~ 4.184×10^{-15} kg/m^{2}s. Energy flux is then ~ $0.5\times[4.184\times10^{-15}\text{ kg/m}^2\text{s}]\times[500\,000\text{ m/s}]^2 = 5.23\times10^{-4}$ W/m^2. Energy loss on gravity is ~ $[4.184\times10^{-15}\text{ kg/m}^2\text{s}]\times[274\text{ N/kg}]\times[6.963\times10^8\text{ m}] \approx 7.98\times10^{-4}$ W/m^2 (here ~274 N/kg is gravity at Solar surface and ~6.963×10^8 m is radius of Sun). Thus, total energy loss on Solar wind is ~ 1.321×10^{-3} W/m^2. From modern Solar constant, 1361 W/m^2, redshift of Solar light is Z ~ 0.001321/1361 ≈ 10^{-6}, which coincides with spectral measurements (see Pivovarov, 2016).

With modern Solar constant, L = 1361 W/m^2 (Wikipedia 2018a), average distance to the Sun, r = 1 au = 1.4959787×10^{11} m, and Solar redshift Z = 10^{-6}, absolute luminosity of Sun may be calculated as

$$\Lambda_{Sun} = 3.828\times10^{26}\text{ W} \qquad (9)$$

From this value, mass defect of Sun is ~Λ_{Sun}/c^2 = 4.259 billions kg per second. Molar mass of ^{1}H is 1.00782503224 g/mol (Wikipedia 2018b), whereas molar mass of ^{4}He is 4.00260325415 g/mole (Wikipedia 2018c). Thus mass defect is 0.028696874 g/mol ^{4}He = 0.71185159 wt % of thermonuclear fuel (i.e. hydrogen). Consequently, our Sun spends on light emission 598.3 billions kg of hydrogen per second or 1.888×10^{19} kg of hydrogen per year. Mass loss on Solar wind is ~ $[4.184\times10^{-15}\text{ kg/m}^2\text{s}]\times4\pi\times[1.4959787\times10^{11}\text{ m}]^2$ = 1.177 billions kg per second = 3.7×10^{16} kg per year. Thus, shining time of our Sun is ~$1.98855\times10^{30}/1.8917\times10^{19}$ = 105 Gy (1 Giga-year = 1 billion of years = 10^9 years). Taking into account for composition of photosphere (~ 25 wt % of He), age of our Sun is about 26 Gy. Beautiful age!

SPECTRUM, ENERGY AND SIZE OF SN 2011fe

Fig. 2 shows extraterrestrial spectrum of Supernova 2011fe at peak luminosity, as measured by Mazzali et al (2014) at 10 September of 2011 year of Universal time (= Greenwich time ± few relativistic seconds), with use of Hubble Space Telescope. Spectrum was (?) “reduced following standard procedures”, “calibrated”, “extracted”, “fringe removed”, “bad pixel removed”, “corrected on saturation”, and “corrected on recession velocity” by Mazzali et al, (2014). It should be also noted, that spectrum shown in Fig. 2 was significantly rarified by present author. Besides, data were presented graphically, so there is some uncertainty in reproduction.

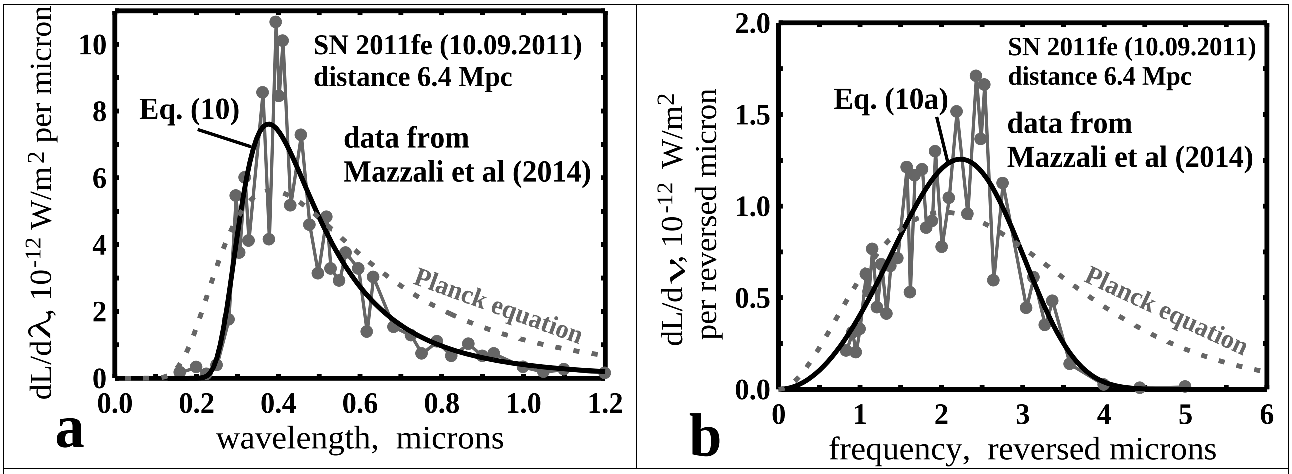

Fig. 2 Extraterrestrial peak spectrum of Supernova SN 2011fe on (a) wavelength (microns) and (b) frequency (reversed micron) scales. Data from Mazzali et al. (2013). Dashed curves: Planck equation (Eq. 3). Black solid curves: Eqs. (10, 10a) with A = 0.4145×10^{-12} and C = 0.3762.

In application to Supernova 2011fe spectrum, black body model fails (see dashed curves), whereas Eq (7) is reduced to:

$$dL/d\lambda,\ \mathrm{W/m^2\ per\ micron} \approx A/[\lambda,\ \mu m]^4/\exp\{(C/[\lambda,\ \mu m])^4\} \qquad (10)\ \text{or}$$

$$dL/d\nu,\ \mathrm{W/m^2\ per\ reversed\ micron} \approx A[\nu,\ 1/\mu m]^2/\exp\{(C[\nu,\ 1/\mu m])^4\} \qquad (10a)$$

Here A = 0.4145×10^{-12} and C = 0.3762 are averaged best-fit parameters. From parameter B ~ 0, temperature of Supernova is “very high”. May be, millions K. However, large spectral lines indicate presence of atoms, and thus, much lower temperature. As estimated by Mazzali et al (2014), temperature of SN 2011fe at peak luminosity was 14500 K.

Integer to model curve is, exactly:

$$L_{2011fe} = \{\Gamma(0.75)/4\}\times A/C^3 \quad = 2.385\times10^{-12}\ \mathrm{W/m^2} \qquad (11)$$

Here L_{2011fe} is apparent peak luminosity of SN 2011fe, Γ(0.75) = 1.225416702465178… is gamma-function of 0.75.

Absolute luminosity of distant object may be calculated from:

$$\Lambda = L\times4\pi r^2\times(1+Z) \qquad (12)$$

Host of SN 2011fe is galaxy M101, located right above the tail of Big Bear (Ursa Major). Distance to galaxy M101 is r = 6.4 Mpc = 1.975×10^{23} m. With Hubble constant H = 72 km/c per Mpc (Freedman et al, 2001) and speed of light, c = 299792.458 km/s, cosmological redshift of M101 may be estimated as Z ~ r×H/c = 0.00154. However, spectrum was “corrected on recession velocity” by Mazzali et al (2013), and thus, redshift may be neglected.

Consequently, absolute peak luminosity of SN 2011fe is:

$$\Lambda_{2011fe} = 2.385\times10^{-12}\times4\pi\times(1.975\times10^{23})^2 = 1.169\times10^{36}\text{ W} = 3.054\text{ billions of Suns} \quad (13)$$

This value is close to absolute peak luminosity of SN 2011fe, measured by Zhang et al (2016): 1.122×10^{36} W = 2.931 billions of Suns, and that measured by Pereira et al (2013): 1.177×10^{36} W = 3.075 billions of Suns. Besides, it is close to average Perlmutter et al's (1999) Supernova, ~3.26 billions of Suns, as roundly guessed by Pivovarov (2018a). Thus, peak specter of SN 2011fe may be used as "standard curve".

In Fig. 3, absolute light curve of Supernova 2011fe is shown (open circles), as measured by Pereira et al (2013). Original time scale was adjusted to best-fit origin (3 h 13 min 25 August 2011 of Greenwich time). Dashed curve in Fig. 3 is approximation from previous study (Pivovarov 2017):

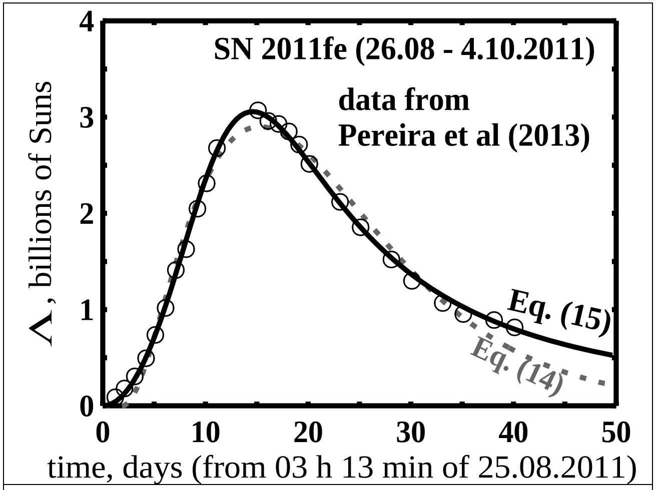

Fig. 3 Absolute light curve of SN 2011fe. Data from Pereira et al (2013). 1 billion of Suns = 3.828×10^{35} W. Solid curve: Eq. (15). Dashed curve: Eq (14).

$$\Lambda=\text{const}\times t^2/\exp\{2\times t/t_{rise}\} \quad (14)$$

Here t is time from burst, const is adjusting parameter, t_{rise} is best-fit rising time. However, this approximation seems to be uncertain. More accurate fit to data was obtained with use of approximation:

$$\Lambda = 2\Lambda_{peak}\times(t/t_{rise})^2/(1+(t/t_{rise})^4) = 2\Lambda_{peak}/\{(t_{rise}/t)^2+(t/t_{rise})^2\} \quad (15)$$

Here Λ_{peak} = 3.056 billions of Suns is best fit peak luminosity, t_{rise} = 14.60 days is best fit rise time, t is time from best fit origin (03 h 13 min 25 August 2011).

Integer sum to Eq (15) is, exactly:

$$E_{2011fe} = (\pi/2^{0.5})\times\Lambda_{peak}\times t_{rise} = 99.12\text{ billions of Solar days} = 3.28\times10^{42}\text{ J} \quad (16)$$

From energy of SN 2011fe, mass defect may be estimated as $E/c^2 = 3.65\times10^{25}$ kg. "Efficiency" of thermonuclear fuel is ~ 0.8 wt % (mass defect of ^{1}H fuel is ~ 0.712÷0.892 % of fuel mass, depending on product of nuclear synthesis, ^{4}He or ^{56}Fe). Thus, mass of exploded hydrogen may be estimated as ~ $3.65\times10^{25}/0.008 = 4.56\times10^{27}$ kg = 0.229 % of Solar mass. With loss of 0.229 wt % of hydrogen, central star becomes older by ~ 0.241 Gy. However, mass of generated C, O, Si, etc elements is enough for creation of ~ 1.7 "planetariums" (total mass of planets of Solar system is ~ 2.67×10^{27} kg = 0.134 % of Solar mass).

Average kinetic energy of a particle is $E = mv^2/2 = 1.5kT$, and heat capacity of ideal gas is 1.5×R = 12.4716 J/K per mole (here R = 8.3144 J/(mol×K) is gas constant). Thus, heat capacity of proton-electron plasma is 24747 J/K per kg. Energy of dissociation of hydrogen is 2.143×10^8 J/kg (=432068 J/mol H_2), energy of ionization of hydrogen is 13.017×10^8 J/kg (= 1312049 J/mol H). Thus, with temperature 14500 K (Mazzali et al, 2014), total mass of molecular cloud, excited by gamma spark from central star of SN 2011fe may be estimated as ~ $3.28\times10^{42}/(1.516\times10^9 + 24747\times T) = 1.7495\times10^{33}$ kg = 880 Solar masses.

Most popular mass of spark is about ~ 1.4 Solar masses. If so, peak temperature of hot plasmatic cloud may be estimated at ~ 47.5 millions K. However, because of interaction of “hot light” with others ~ 879 Solar masses of cold molecular cloud, we see typical “blue sky” spectrum of type Ia Supernova.

Because the light from distant objects “not exhibit blurring” (Wikipedia, 2018d), size of distant object may be estimated directly from photos:

$$R_{object} = r\times\sin(\alpha) \qquad (17)$$

Here R_{object} is radius of object, r is distance to object, and α is angular radius of object (1/2 of angular size). For instance, from mean angular radius of Sun, ~16 arcminutes, radius of Sun may be estimated as ~ $(1.4959787\times10^{8}$ km$)\times\sin(16/60) = 696258$ km.

As may be seen in photo made by Zhang et all (2016) at 20 September, SN 2011fe is spot with radius ~ 2 mm. From given scale, 2 arcminutes = 26 mm, angular radius of SN 2011fe is ~ 0.15385 arcminutes = 9.231 arcseconds. Thus, apparent radius of SN 2011fe is $R_{2011fe} = (6.4\times10^{6}$ pc$)\times\sin(0.15385/60) = 286.4$ pc = 934 light years (!!!!).

In Fig. 4, apparent radius of SN 2011fe is shown in comparison with transformed absolute light curve from Fig. 3. As may be seen, apparent size of SN 2011fe from photos made by Brimacombe (2011) is closely consistent with correlation:

$$\text{Apparent radius, light years} \sim 780\times[\Lambda, \text{billions of Suns}]^{1/4} \qquad (18)$$

Thus, it is highly likely that the light from distant objects “exhibit blurring” due to interaction with interstellar, intergalactic, then again interstellar, and, finely, atmospheric media. Besides, it is possible that “hot pixels” export collected light energy to neighboring pixels, and resulting diffusion of absorbed energy during exposition gives image with diffuse-like rising, ~ $t^{0.5}$, and apparent “gravitation collapse” after peak luminosity. Note that the best-fit factor 780 in Eq (18) varies with applied equipment (and, may be, exposition). For instance, apparent radius of SN 2011fe on photos made by Llapasset (2011) is smaller (best fit factor in Eq (18) is 670: see dashed curve in Fig. 4). What is about of real size of SN 2011fe?

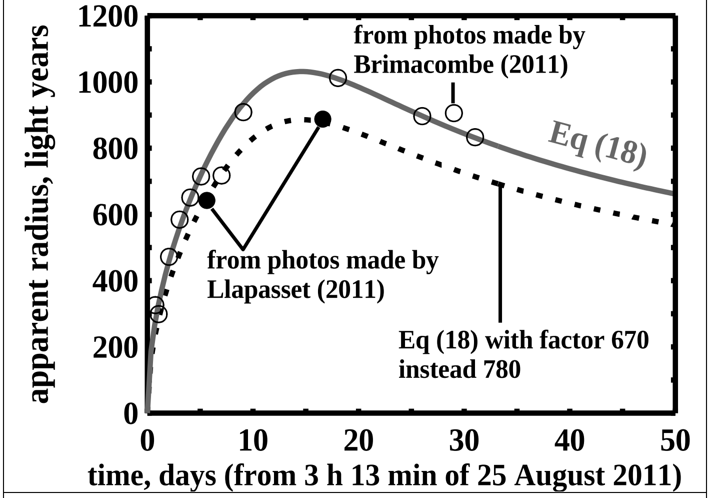

Fig. 4 Apparent radius of SN 2011fe.

In Fig 5, infrared light curve of SN 2011fe is shown, as measured by Zhang et al (2016). Original data, measured in infrared magnitudes, were converted to arbitrary flux scale via relation:

$$F, \text{arbitrary units} = 10^{\wedge}(-0.4(m-10)) \qquad (19)$$

Here F is “flux”, i.e., infrared luminosity in arbitrary units, m is measured infrared magnitude, and second number 10 is arbitrary constant. Original time scale was adjusted to best-fit origin (22 h 54 min of 23 August of 2011 of Greenwich time). From present fit, infrared emission appeared ~ 1 day and 4 h earlier than visible emission.

As may be seen, infrared light curve contains second peak at ~ 44 day from origin. Note that second peak on infrared light curve is mostly typical for nearest Supernovae. Typically, small second peak may be also detected on red light curves of nearest Supernovae, and there is no such feature on light curves, measured with B (blue) and V (visually colorless) light filters.

Solid curve in Fig. 5 was calculated as sum of two light curves (see Eq. 15): Main peak with origin at 0 day (22 h 54 min of 23 August of 2011) and Second peak with best fit origin at 26.79 day (i.e. at 17 h 52 min of 19 September 2011):

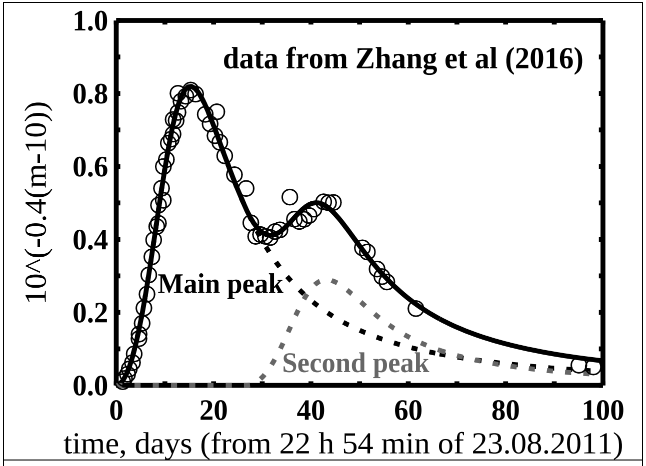

Fig. 5. Infrared emission from SN 2011fe (arbitrary units). Data from Zhang et al (2016).

$$\text{Main peak} = 2\times0.8193\times([t, \text{days}]/15.24)^2/(1+([t, \text{days}]/15.24)^4) \qquad (20)$$

$$\text{Second peak} = 2\times0.2897\times([t, \text{days}]/16.39)^2/(1+([t, \text{days}]/16.39)^4) \qquad (21)$$

One may guess that second spark was initiated at ~ 26.79 day by gravitational collapse of central star, partly destroyed by first burst. If so, peak radius of spark may be guessed at ~ 0.35 au (26.79 / 2 = 13.395 days is time of free fall to the Sun from distance 0.3506 au).

From the other hand, second peak may be explained as remainder of emission from back side of gas cloud around central star. If so, from date of second peak (at ~ 44 day, see Fig 5), peak radius of plasmatic cloud, excited by gamma emission from central star, may be guessed at ~ 22 light days = 5.6985×10^{11} km = 3809 au, which is close to inner radius of Oorth cloud around the Sun, 2500-5000 au. Oort cloud (Wikipedia, 2018e) is extended up to 0.8 ÷ 3.2 light years from the Sun. So, may be, upon 1 year from burst, in spite of low luminosity (~ 2 millions of Suns: see Zhang et al, 2016), radius of SN 2011fe was also about ~ 1 light year.

Oort cloud consists of comets, micro-planets, ice and silicate dust and vapor above these gravity-less objects. Estimated mass of Oort cloud is only ~ 5 ÷ 380 Earth masses (Wikipedia 2018e). If so, Oort cloud is just a remainder of Mother Cloud of our Sun.

However, as may be guessed from Pioneer's anomaly (see Pivovarov, 2018b), above Saturn orbit (~ 10 au from Sun), density of Space rises to ~ 1.34×10^{-16} kg/m^3. Sphere with radius 1 light year = 9.46×10^{15} m and density 1.34×10^{-16} kg/m^3 has mass 475×10^{30} kg = 239 Solar masses. Because of low temperature and low column density, ~ 0.000127 Air mass, this massive object is weakly detectable. However, massive and cold molecular cloud around the Sun may be responsible for cosmic microwave background radiation with "black body" temperature ~ 2.7 K.

Thus, may be, our Grand-Ma Cloud is still with us. May be, about ~ 5-10 billions of years ago, conflict between Mother Cloud and young Sun resulted into Homeric scandal, evident in whole Universe. May be, because of regular feeding, Child Sun was like a Red Giant, and its gravitational collapse was followed by gamma-spark. And Mother Cloud, dressed in blue, gone aside, leaving young Sun with wonderful family of new-born planets. As soon conflict was settled, Mother Cloud returned to Saturn orbit, as allowed by light of our Queen of Heaven.

CORRECTION OF TERRESTRIAL SPECTRA

In Fig. 6, extraterrestrial spectrum of Sun from Johnson (1954) is compared with terrestrial spectrum measured by Stair et al (1954) at optical density of atmosphere 1 Air mass (= 1 kg/cm^2). The model curve for terrestrial spectrum is (see grey curve in Fig 6):

$$dL/d\lambda,\ \text{W/m}^2 \text{ per micron} = [\text{extraterrestrial spectrum}]/\exp\{(0.29/[\lambda, \mu\text{m}])^3\} \qquad (22)$$

Here 0.29 is best fit parameter. Similar fit to data may be obtained with permeability factor of atmosphere ~ $0.9/\exp((0.28/\lambda)^4)$. However, empirical term $1/\exp\{(0.29/[\lambda, \mu m])^3\}$ is simpler.

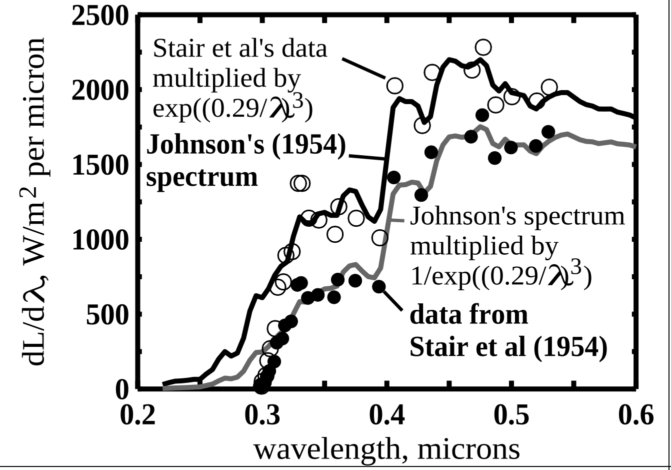

Fig 6 Terrestrial spectrum of Sun, measured by Stair et al (1954) at air mass 1 (solid points), compared with Johnson's (1954) extraterrestrial spectrum of Sun (black curve).

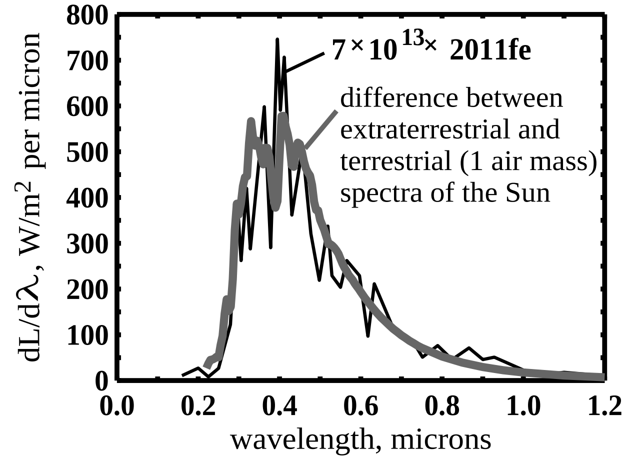

Fig 7 Difference between extraterrestrial and terrestrial spectrum at air mass 1 (gray curve), compared with peak spectrum of SN 2011fe, multiplied by factor 7×10^{13} (black curve).

So on, spectral permeability factor for "clear atmosphere" may be approximated by:

$$p \approx 1/\exp\{D(0.29/[\lambda, \mu m])^3\} \qquad (23)$$

Here D is "air mass" (i.e. optical density of atmosphere in kg per cm^2).

Neglecting curvature of the Earth, air mass may be calculated from:

$$D\text{, air mass} \approx \{P, kg/cm^2\}/\sin(\alpha) = 1.033227453\times\{P, Atm\}/\sin(\alpha) \qquad (24)$$

Here $\{P, kg/cm^2\}$ is atmospheric pressure in kg/cm^2 (1 kg/cm^2 = 98066.5 Pa), $\{P, Atm\}$ is atmospheric pressure in standard atmospheres (1 Atm = 101325 Pa = 760 mm Hg), and α is angle between optical axis of telescope and horizontal plane. Within the range $\alpha = 30\text{-}90^o$, Eq (24) is almost exact. However, for object at horizon ($\alpha = 0^o$), Eq (24) gives infinity instead of ~ 40 air masses.

Fig. 7 shows the difference between extraterrestrial and terrestrial spectrum of Sun at air mass 1, compared with peak spectrum of SN 2011fe, multiplied by factor 7×10^{13}. As may be seen, SN 2011fe looks like a particle of blue sky, indicating secondary nature of emission.

ABSOLUTE LUMINOSITY OF DISTANT SUPERNOVAE

As may be seen in Fig 3, it is difficult to catch Supernova at peak luminosity. From Eq (15), spectra measured at phase – 2.1 to + 2.5 days (phase is date of spectrum with respect to peak), may be considered as "almost peak" with error 5 % or smaller.

Fig. 8 shows "almost peak" terrestrial spectra of 2011fe-like Supernovae of type Ia from Balland et al (2009), compared with spectrum of SN 2011fe, converted to the same redshift and air mass. Note that data were presented graphically, and there is some uncertainty in reproduction. Transformation of SN 2011fe peak spectrum was performed in accordance with:

Step 1: $$\lambda_Z = \lambda_{2011fe}\times(1+Z) \qquad (25)$$

Step 2: $$(dL/d\lambda)_Z = (dL/d\lambda)_{2011fe}\times(6.4/\{4164\times\ln(1+Z)\})^2/(1+Z)^2/\exp\{D(0.29/[\lambda, \mu m])^3\} \qquad (26)$$

Here 6.4 is distance (Mpc) to SN 2011fe, $4164\times\ln(1+Z)$ is distance (Mpc) to object (see Eq. 2), factor $1/(1+Z)^2$ is scale × redshift correction, $1/\exp\{D(0.29/[\lambda, \mu m])^3\}$ is correction on air mass.

Note here that scale correction in Eq. (26) is conversion of (dL/dλ) from intermediate scale, W/m^2 per (1+Z)×micron, arising dew to Step 1, to normal scale, W/m^2 per micron.

"Almost peak" absolute luminosities of Supernovae from Fig. 8 are listed in Tab. 1. From these data, absolute peak luminosity of average "standard candle" is ~ 2.07 billions of Suns. With correction on phase, it is 2.11 billions of Suns. Thus, resent result, 3.26 billions of Suns (Pivovarov, 2018a) is overestimated. However, total luminosity of distant Supernova, guessed from one color magnitude (red or, may be, infrared) with error 35 % seems to be a close hit.

Note here that value 2.11 billions of Suns is model-dependent. True value is $2.11\times(72/H)^2$ billions of Suns, where 72 km/s per Mps is Hubble constant, applied in present study, and H is "exact" value. For instance, if SN 2011fe is really average "normal" Supernova of type Ia, "exact" Hubble constant may be estimated as 60 km/s per Mps. Otherwise, with H = 500 km/s per Mps (Hubble, 1929), average "standard candle" drops to 44 millions of Sun.

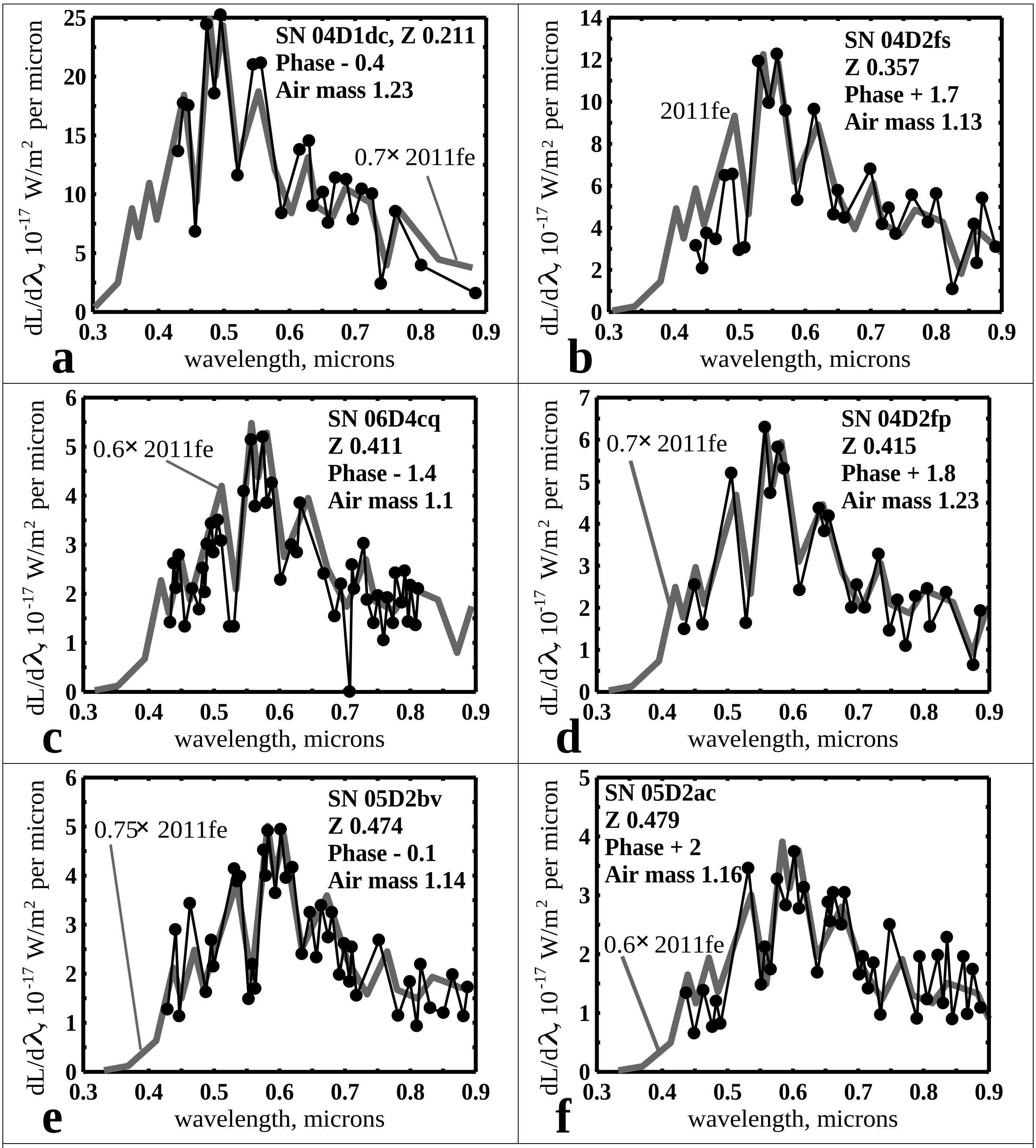

Fig. 8 "Almost peak" terrestrial spectra of "normal" Supernovae of type Ia from Balland et al (2009), compared with peak spectrum of SN 2011fe, converted to the same redshift and air mass.

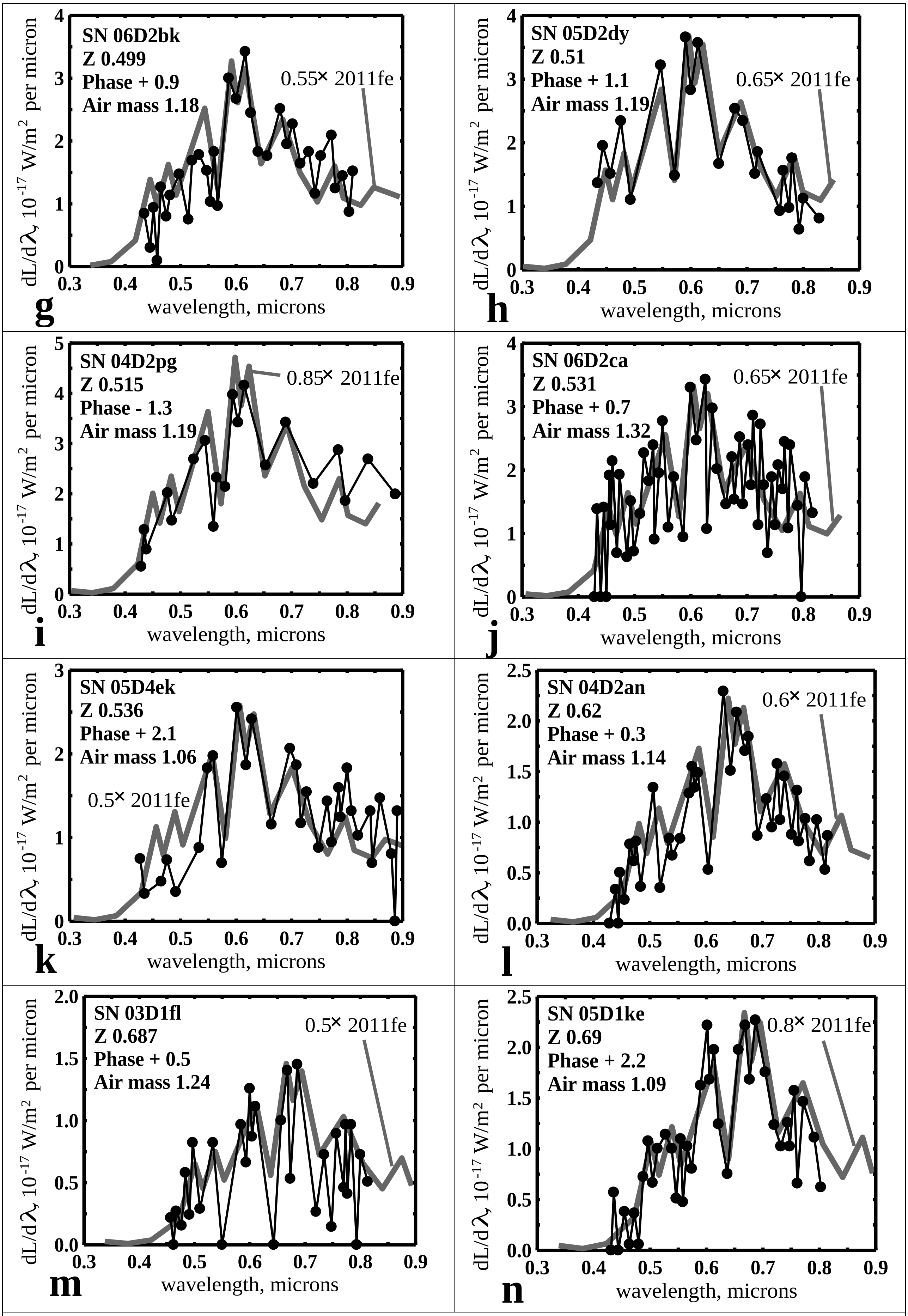

Fig. 8 (continued)

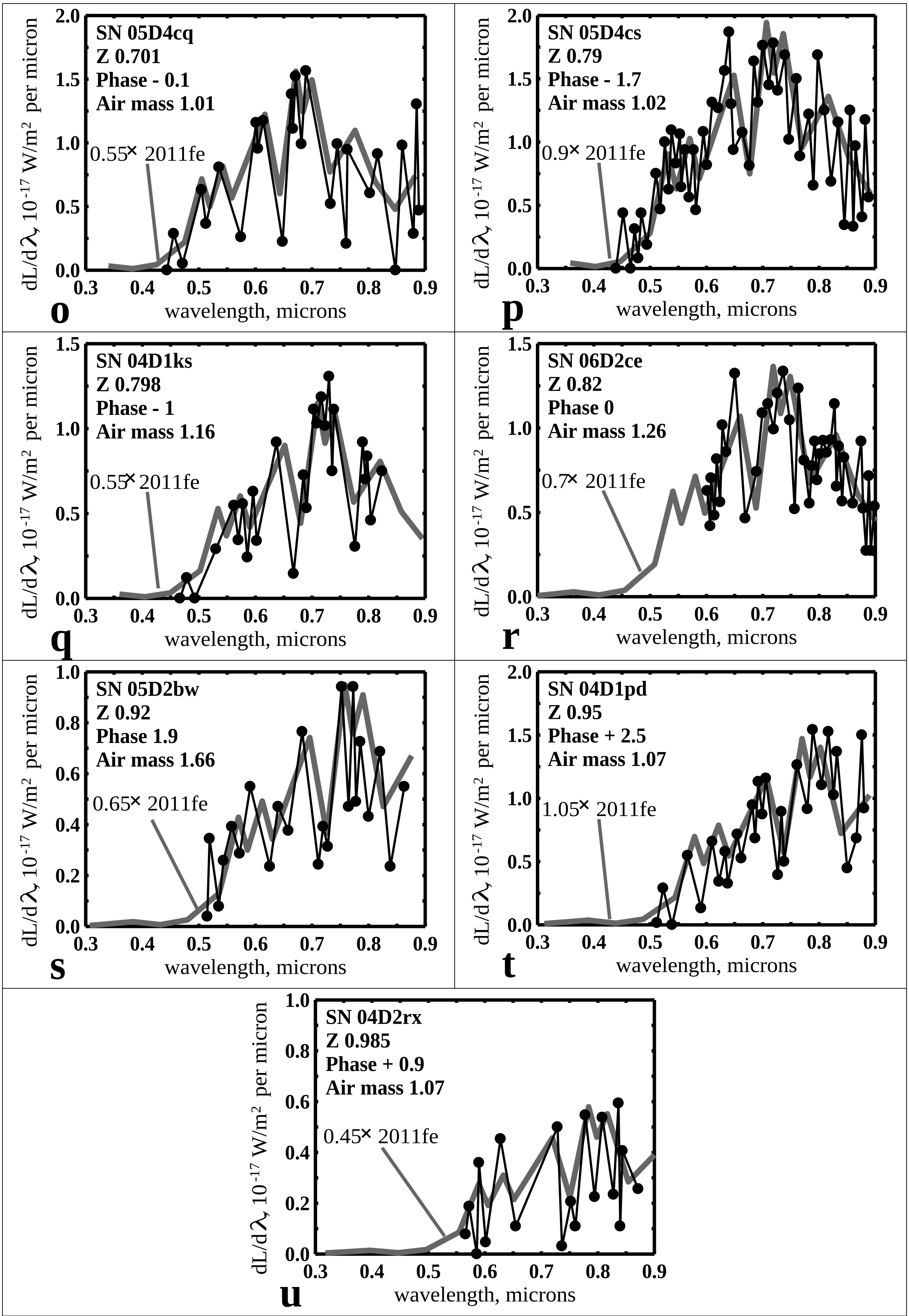

Fig. 8 (continued)

Tab 1 “Almost peak” absolute luminosities of “normal” Supernovae of type Ia.

SN Name[a]	Redshift[a] Z	Phase[a] f, days	Air mass[a] D, kg/cm^2	Absolute luminosity[b], Λ, number of 2011fe	Absolute luminosity[b], Λ, billions of Suns
04D1dc	0.211	- 0.4	1.23	0.7	2.14 (2.14[c])
04D2fs	0.357	+1.7	1.13	1	3.05 (3.13[c])
06D2cq	0.411	-1.4	1.1	0.6	1.83 (1.87[c])
04D2fp	0.415	+1.8	1.23	0.7	2.14 (2.20[c])
05D2bv	0.474	-0.1	1.14	0.75	2.29 (2.29[c])
05D2ac	0.479	+2	1.16	0.6	1.83 (1.89[c])
06D2bk	0.499	+0.9	1.18	0.55	1.68 (1.69[c])
05D2dy	0.51	+1.1	1.19	0.65	1.99 (2.01[c])
04D1pg	0.515	-1.3	1.19	0.8	2.44 (2.48[c])
06D2ca	0.531	+0.7	1.32	0.65	1.99 (2.00[c])
05D4ek	0.536	+2.1	1.06	0.5	1.53 (1.59[c])
04D2an	0.62	+0.3	1.14	0.6	1.83 (1.83[c])
04D2fl	0.687	+0.5	1.24	0.5	1.53 (1.53[c])
05D1ke	0.69	+2.2	1.09	0.8	2.44 (2.54[c])
05D4cq	0.701	-0.1	1.01	0.55	1.68 (1.68[c])
05D4cs	0.79	-1.7	1.02	0.9	2.75 (2.83[c])
04D1ks	0.798	-1	1.16	0.55	1.68 (1.70[c])
06D2ce	0.82	0	1.26	0.7	2.14 (2.14[c])
05D2bw	0.92	+1.9	1.66	0.65	1.99 (2.05[c])
04D1pd	0.95	+2.5	1.07	1.05	3.21 (3.37[c])
04D2rx	0.985	+0.9	1.07	0.45	1.37 (1.38[c])
average	-	-	-	0.67857	2.07 (2.11[c])

[a] Balland et al (2009); [b] present study (see Fig 8)

[c] estimated peak absolute luminosity: from phase, Eq (15), and rising time ~ 14.6 days

Tab. 2 “Almost peak” absolute luminosity of “overluminous” Supernovae.

SN Name[a]	Redshift[a] Z	Phase[a] f	Air mass[a] D	Absolute luminosity[b], Λ, number of 2011fe	Absolute luminosity[b], Λ, billions of Suns
05D1hk	0.263	- 5	1.07	2.6	7.94 (9.29[c])
04D4ib	0.699	+0.7	1.24	3.3	10.08 (10.10[c])
03D4cx	0.949	+2.7	2.15	3	9.16 (9.46[c])
04D4jw	0.961	+2.2	1.04	3.1	9.47 (9.68[c])
04D4dw	1.031	+2.1	1.06	3.4	10.38 (10.59[c])
Average	-	-	-	3.08	9.41 (9.82[c])

[a] Balland et al (2009); [b] present study (see Fig 9)

[c] estimated absolute peak luminosity: from phase, Eq (15), and rising time guessed at ~ 20 days.

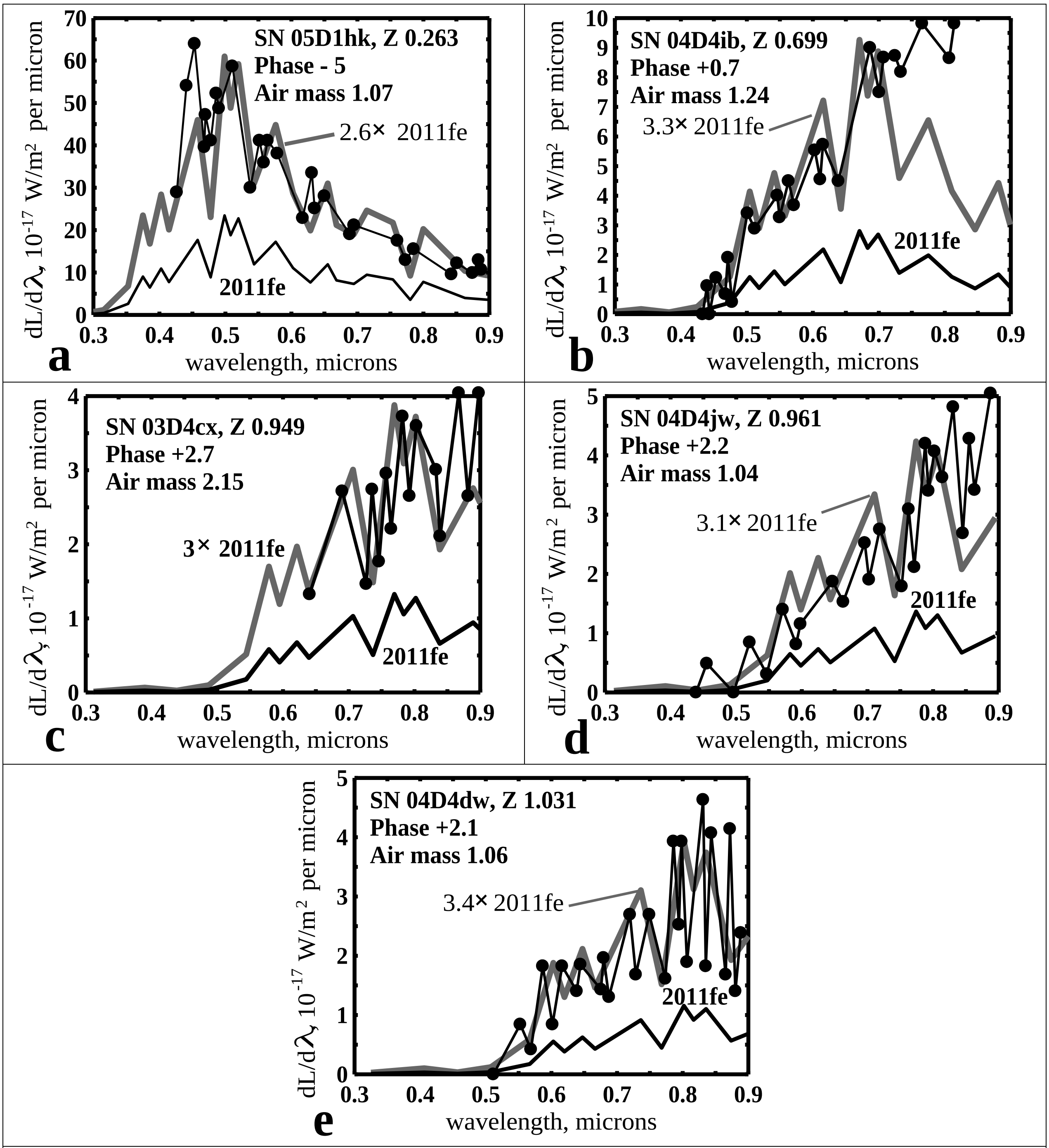

Fig 9 Terrestrial spectra of overluminous Supernovae of type Ia from Balland et al (2009), compared with spectrum of SN 2011fe, converted to the same redshift and air mass.

There are also several overluminous Supernovae of type Ia (see Fig. 9 and Tab 2), measured by Balland et al (2009). In opinion of Balland et al (2009) these spectra are strongly contaminated by billions of stars in host galaxies, and these Supernovae are roundly normal ones. However, background was not measured. In any way, absolute peak luminosities of all these "overluminous objects" are roundly identical. As may be seen in Fig. 9 and Tab 2, "overluminous objects" are specified by absolute luminosity ~ 3.08×2011fe ≈ 9.41 billions of Suns. Smallest overluminous Supernova (05D1hk, see Fig 9a), with absolute luminosity ≈ 7.94 billions of Suns, was measured 5 days before maximum. Thus, guessing total rising time as t_{rise} ~ 20 days, peak luminosity may be calculated from Eq. (15) as 9.29 billions of Suns. Applying the same correction to other "overluminous" Supernovae (see Tab 2), average absolute peak luminosity may be adjusted to 9.82 billions of Suns or, truly, $9.82\times(72/H)^2$ billions of Suns.

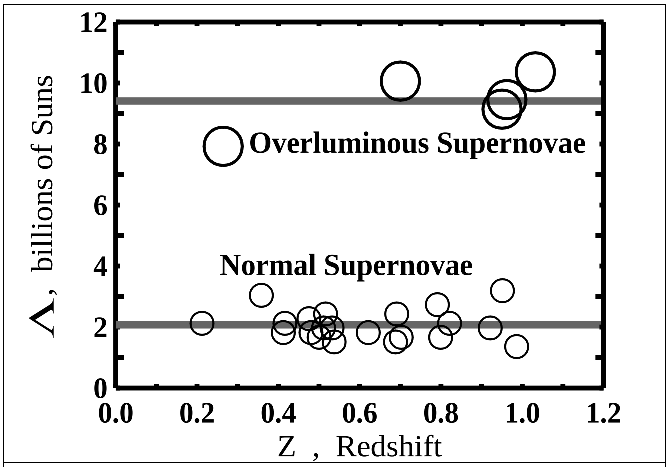

Fig. 10 "Almost peak" absolute luminosities of normal (see Fig. 8 and Tab. 1) and overluminous (see Fig. 9 and Tab. 2) Supernovae of type Ia.

Fig 10 shows absolute luminosities of distant Supernova versus redshift. As may be seen, estimated absolute luminosities of "normal" and "overluminous" Supernovae are well consistent with Stewart-Brown law (Eq. 2). Thus, theory of Tired Light is true.

Stars generate helium, carbon, oxygen, silicon, iron, and etc. So, why Eternal and Infinite Universe does not consist of the most stable element, iron? Mass of ^{56}Fe is 55.9349363 g/mol (Wikipedia 2018f). Mass of ^{1}H is 1.00782503224 g/mol (Wikipedia 2018b). Thus, synthesis of ^{56}Fe atoms from hydrogen is followed by mass defect $\Delta m = 0.503265554$ g/mol ^{56}Fe, and energy $E \sim \Delta m \times c^2 = 4.523125 \times 10^{13}$ J/mol ^{56}Fe. Consequently, energy-average thermal velocity (from $E = Mv^2/2$) of ^{56}Fe atoms may be estimated as $v = (2 \times 4.523125 \times 10^{13}/0.0559349363)^{0.5} = 40215430$ m/s, and temperature of ^{56}Fe gas may be estimated as $(2/3) \times E/R = 3.63 \times 10^{12}$ K (here $R = 8.3144$ J/(mol×K) is gas constant). Evidently, collision of iron atoms should result into immediate disintegration of "Iron Universe".

Thus, there is Universal equilibrium between nuclear synthesis in stars and disintegration somewhere in free space. Based on mass action law ($Fe \Leftrightarrow 56H$; $[Fe] = const \times [H]^{56}$) and huge energy of nuclear synthesis (~ 4.523125×10^{13} J/mol Fe), regions of disintegration should have large temperature and low particle density. Perhaps, most effective regenerator of thermonuclear fuel is intergalactic plasma with temperature $10^5 - 10^7$ K (Fang et all, 2010) and low density (may be, about ~ 1 proton-electron pair per dm^3 = 1.67356×10^{-24} kg/m^3).

CONCLUDING REMARKS

Based on analysis of spectral data, average absolute peak luminosity of "normal" distant Supernovae of type Ia is ~ 2.11 billions of Suns, and that of "overluminous" Supernovae is ~ 9.82 billions of Suns. Redshift-luminosity relation in both subgroups of Supernovae is consistent with Theory of Tired Light. NO BIG BANG!!! UNIVERSE FOREVER!!!

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