International Journal of Astronomy and Astrophysics, 2016, 6, 272-275
Published Online September 2016 in SciRes. http://www.scirp.org/journal/ijaa
http://dx.doi.org/10.4236/ijaa.2016.63022

Modelling and Analysis of the Hubble Diagram of 280 Type SNIa Supernovae and Gamma Ray Bursts Redshifts with Analytical and Empirical Redshift/Magnitude Functions

Laszlo A. Marosi

67061 Ludwigshafen am Rhein, Germany
Email: LaszloMarosi@aol.com

Received 20 July 2016; accepted 28 August 2016; published 31 August 2016

Abstract

Based on an analysis of 280 Type SNIa supernovae and gamma-ray bursts redshifts in the range of z = 0.0104 - 8.1 the Hubble diagram is shown to follow a strictly exponential slope predicting an exponentially expanding or static universe. At redshifts > 2 - 3 ΛCDM models show a poor agreement with the observed data. Based on the results presented in this paper, the Hubble diagram test does not necessarily support the idea of expansion according to the big-bang concordance model.

Keywords

Magnitude, Redshift Data Fitting, Supernovae, Gamma Ray Bursts, Hubble Diagram, ΛCDM Cosmological Model

1. Introduction

Based on an analysis of 280 Type SNIa supernovae and gamma ray bursts redshift (z) data Marosi [1] has shown that the best-fit function to represent the observational z/extinction-corrected distance moduli (μ) data set is the exponential equation $\mu = 44.109769 \times z^{0.059883}$. Recently, a number of papers have appeared proposing different analytical formulae for describing the experimental z/μ relationship: Sorrell [2], Vigoureux, Vigoureux and Langlois [3] Traunmüller [4] and Churoux [5]. In this paper, observed z/μ data of 280 Type SNIa supernovae and

How to cite this paper: Marosi, L.A. (2016) Modelling and Analysis of the Hubble Diagram of 280 Type SNIa Supernovae and Gamma Ray Bursts Redshifts with Analytical and Empirical Redshift/Magnitude Functions. *International Journal of Astronomy and Astrophysics*, **6**, 272-275. http://dx.doi.org/10.4236/ijaa.2016.63022

gamma ray bursts in the range of $z = 0.0104$ - 8.1 are compared to results calculated on the basis of these theoretically derived and empirical functions and the Lambda cold dark matter (ΛCDM) model. The aim of this paper is to examine which of the above functions and models fits the observations more accurately. We expect that in the high RS range it should be possible to decide whether the Hubble diagram follows the distance/z relationship as predicted by the ΛCDM model, or the exponential tired light formula.

2. Data Collection and Processing

The z/μ data set consists of 171 gold-set data, Riess *et al.* [6], and 109 cosmology independent calibrated gamma-ray bursts (GRB) data consisting of 59 high-RS data (Hymnium data set) and 50 low RS GRBs obtained by Wei [7] from the 557 Union 2-compilation.

The following mathematical functions and cosmological models were used to perform a global fitting over the RS range of $z = 0.0104$ - 8.1.

$$\mu = 44.109 z^{0.0598} \quad \text{(Marosi, 2014)} \tag{1}$$

$$\mu = 25 + 5\log\left(c/H_0\right) + 5\log\left(\left(z+1\right)\ln\left(z+1\right)\right) \quad \text{(Vigoureux \textit{et al.}, 2014)} \tag{2}$$

$$\mu = 2.5\log\left(\left(z+1\right) r_u^2 z^2\right) \quad \text{(Churoux, 2015)} \tag{3}$$

$$\Lambda\text{CDM model with } H_0 = 62.5\ \text{km}\cdot\text{s}^{-1}\cdot\text{Mpc}^{-1},\ \Omega_m = 0.286,\ \Omega_\Lambda = 0.732 \text{ and } k = 0 \tag{4}$$

$$\Lambda\text{CDM model with } H_0 = 72.6\ \text{km}\cdot\text{s}^{-1}\cdot\text{Mpc}^{-1},\ \Omega_m = 0.286,\ \Omega_\Lambda = 0.732 \text{ and } k = 0 \tag{5}$$

The μ values on basis of the ΛCDM models were calculated using:

$$\mu = -5 + 5\log D_L, \tag{6}$$

where D_L (Pc) is the luminosity distance. The luminosity distances were calculated using the cosmological calculator described by Wright [8].

For preparing the linear t_S/z Hubble diagram, using Equation (7) the fitted z/μ data were converted into the corresponding t_S/z datasets.

The photon flight-time t_S was calculated using:

$$t_s = \frac{D_c}{c} = \frac{10^{\frac{\mu+5}{5}}}{\left(z+1\right)\times 3\times 10^{10}} \times 3.085\times 10^{18} \tag{7}$$

In Equation (7) t_S means the flight time of the photons (sec.) from the co-moving radial distance D_C to the observer, $t_S = D_C/c$, which is proportional to the D_C (Pc) that goes into the linear Hubble law.

In order to complete the fitted z/μ data set in the high RS range of $t_S \times 10^{-14} = 6000$ - 11000, in addition to the measured RSs, using Equation (2), 41 equidistant t_S/z data points were included into the Hubble diagram. The addition of the 41 additional data points is necessary to perform the $\sum\chi^2$-test between the best fit and the ΛCDM models because only few observations are available in this redshift range. The t_S/RS values were calculated on the basis of Functions (2) and (5).

Excel and Excel Solver were used for data fitting, refinement, and data presentation.

3. Results

Figure 1 shows results of the z/μ data fitting with Functions (1)-(5).

It is easy to see by visual examination of **Figure 1** that there are only minor differences between the fit curves calculated with Functions (1) and (2), whilst the ΛCDM model with H_0 = 72.6 km s^{-1} Mpc^{-1} (bottom line in **Figure 1**) is slightly but perceptibly different.

The most reliable measure to quantify the differences between the individual fit curves turned out to be the $\sum\chi^2$-test. The goodness of fit indicators are shown in **Table 1**.

The $\sum\chi^2$-test obviously favors the trend-lines obtained with Functions (1) and (2) and these two curves are practically congruent. On basis of the data presented in **Table 1** the analytical best-fit Function (2) will be used as the best representation of the observed z/μ data in the following discussion.

Figure 2(a) and **Figure 2(b)** show Hubble diagrams calculated on basis of the Functions (2), (4) and (5).

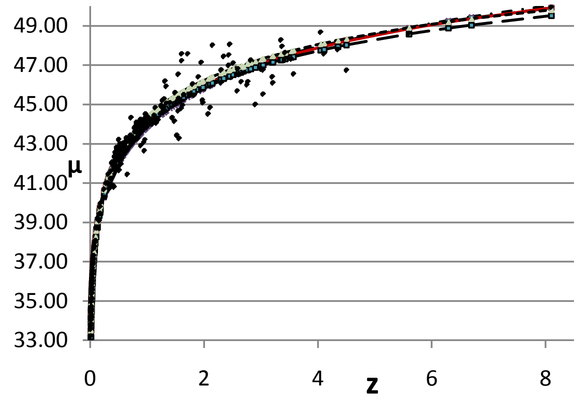
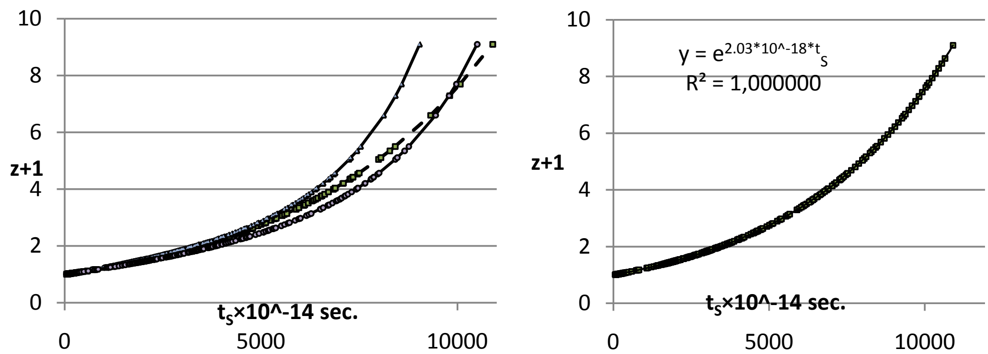


Figure 1. Squares: observed z/μ data; long dash-dot line: (2); solid line: (1); dash-dot line: (3); long dashed line; ΛCDM, $H_0 = 72.6\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$; short dashed line: ΛCDM, $H_0 = 62.5\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$.

Table 1. Goodness of fit indicators of the z/μ data trend-lines.

Function (F)	1	2	3	4	5
$\sum\chi^2$ μ_{obs}-$\mu_{F(1-5)}$	1.958865	1.96555	2.38869	2.163105	2.1582
$\sum\chi^2$ F2-F(1; 3 - 5) %	−0.34	–	17.78	9.57	8.9



(a) (b)

Figure 2. (a) Redshift of type Ia supernovae as a function of $t_S = D_C/c$. Squares (dashed line): t_S/z data inferred from the potential best-fit curve of the observed z/μ diagram. Triangles: t_S/z relationship derived from the ΛCDM model with $H_0 = 72.6\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$, Circles: t_S/z relationship derived from the ΛCDM model with $H_0 = 62.5\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$; (b) squares: t_S/z data inferred from the potential best-fit curve of the observed z/μ diagram, solid line: exponential trend-line (Excel).

4. Discussion

The most important result of the Hubble diagram test is that fitting the t_S/z data with Function (2) and $H_0 = 62.5\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$ (dashed line in **Figure 2(a)**) leads exactly to the exponential function:

$$Z + 1 = \mathrm{e}^{2.03*10^{-18}*t_S} \tag{8}$$

as illustrated in **Figure 2(b)**.

In spite of numerous correction factors and unknown constituents, dark matter (DM) and dark energy (DE), the ΛCDM models show a poor agreement with the observed data: as shown in **Figure 2(a)** the ΛCDM model with $H_0 = 62.5\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$ departs from the best-fit curve for $z + 1 < 6.5$ to the bottom, for $z + 1 > 6.5$ to the upper side of the trend-line. The deviations are of a systematic (nonstatistical) nature and, therefore, the model cannot reflect the observational exponential slope.

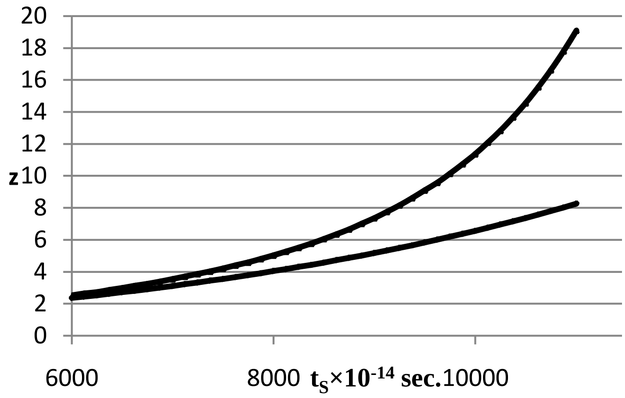


Figure 3. Bottom line: Calculated data points from the best-fit Function (2); upper line: calculated data points for the t_S/z relationship derived from the ΛCDM model with $H_0 = 72.6$ km s^{-1} Mpc^{-1}. From [1].

In the range of $z > 3$ the ΛCDM model with $H_0 = 72.6$ km s^{-1} Mpc^{-1} shows a sharp increase in slope and departs considerably from the observed exponential function. For performing the $\sum\chi^2$-test in the high RS range of $t_S \times 10^{-14} = 6000$ - 11000 (**Figure 3**), using Equation (2), 41 calculated t_S/z data points were included into the Hubble diagram. The $\sum\chi^2$-test leads to a statistical significance between the observed t_S/μ and the calculated ΛCDM data of P = 0.053, indicating that from the statistical point of view, the two models are essentially different.

5. Conclusions

The results presented in this paper have demonstrated that the ΛCDM-model cannot fit the strictly exponential slope of the Hubble diagram in the entire RS range of z = 0.0104 - 8.1, showing that the underlying theory is, at best, incomplete. A reconsideration of the ΛCDM-model appears warranted.

The Hubble diagram test leads to the significant conclusion that either: (1) the universe expanded exponentially during the whole time of its expansion history (at least in the range of $z = 0.0104$ - 8.1); or (2) the universe is static and the RS of spectral lines is caused by some as-yet unidentified mechanism. However, both of these models, the exponentially expanding and the static universe models have their own crucial problems; the discussion of them is not within the scope of this paper.

References

[1] Marosi, L.A. (2014) Hubble Diagram Test of 280 Supernovae Redshift Data. *Journal of Modern Physics*, **5**, 29-33. http://dx.doi.org/10.4236/jmp.2014.51005

[2] Sorrell, W.H. (2009) Misconceptions about the Hubble Recession Law. *Astrophysics and Space Science*, **323**, 205-211. http://dx.doi.org/10.1007/s10509-009-0057-z

[3] Vigoureux, J.M., Vigoureux, B. and Langlois, M. (2014) An Analytical Expression for the Hubble Diagram of Supernovae and Gamma-Ray Bursts. arXiv:1411.3648v1.

[4] Traunmüller, H. (2014) From Magnitudes and Redshifts of Supernovae, Their Light-Curves, and Angular Sizes of Galaxies to a Tenable Cosmology. *Astrophysics and Space Science*, **350**, 755-767. http://dx.doi.org/10.1007/s10509-013-1764-z

[5] Churoux, P. (2015) A New Interpretation of the Hubble Law. *Journal of Modern Physics*, **6**, 1227-1232. http://dx.doi.org/10.4236/jmp.2015.69127

[6] Riess, A.G., Sirolger, A.G., Tonry, J., *et al*. (2004) Type Ia Supernova Discoveries at $z > 1$ from the Hubble Space Telescope: Evidence for Past Deceleration and Constraints on Dark Energy Evolution. *The Astrophysical Journal*, **602**, 665-687. http://dx.doi.org/10.1086/383612

[7] Wei, H. (2010) Observational Constraints on Cosmological Models with the Updated Long Gamma-Ray Bursts. *Journal of Cosmology and Astroparticle Physics*, **2010**, Article ID: 020. http://dx.doi.org/10.1088/1475-7516/2010/08/020

[8] Wright, E.L. (2006) Cosmological Calculator. *PASP*, **188**, 1711-1715, Last Modified 06-12-2014.