The Einstein Universe

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Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT

The Pantheon+ SH0ES data is interpreted using transformed coordinates with distances that have origin at the beginning of the Universe. Distances (R) taken from the beginning of the Universe ($R \sim 0$ and $t \sim 0$) increase toward Earth and reveal a Newtonian Gravitational redshift ($z < 0.1$). Distances determined in this way are the inverse of the luminosity distances measured from Earth. The revised coordinate frame yields a $1/R$ dependence of the redshift consistent with a Newtonian gravitational redshift. An alternative to the Hubble–Lemaitre expanding Universe is presented. The alternative Universe suggested is determined by Gravity, is static in size and contains Galaxies that show a Gaussian distribution of velocities. This is the model of the Universe first considered by Einstein.

Key words: cosmology: theory – cosmology: observations – distance scale – supernovae: general – gravitation

1 INTRODUCTION

Einstein's presentation of general relativity (GR) in 1915 represents a pivotal advance in human thinking (Einstein 1997, 1915a,b, 1916). Furthermore, General Relativity is considered to mark the beginning of modern cosmology (Peebles 1993; Einstein 1917). The physics developed in GR assumes that universal physical laws are independent of reference frame leading to space-time that is curved by gravity (Weinberg 1972).

Einstein developed general relativity assuming a Universe of static size. The cosmological constant was included to allow a static solution (Einstein 1917, 1953). Einstein initially thought that the galaxies behaved like atoms in a gas and that the size of the Universe was static (Einstein 1953). The Hubble data convinced him that the universe was expanding (Hubble 1929; Hubble & Humason 1931). Interpretation of the redshift as a recessional velocity is an obvious conclusion given that the measurements are made from Earth based telescopes. The geocentric view dates to the earliest astronomy, particularly that of Ptolemy of Alexandria (c. AD 100–170) who presented his graphical description of the geocentric Universe in his *Almagest* (Nussbaumer & Bieri 2009; Toomer 1998). Copernicus in his *De Revolutionibus Orbium Coelestium* of 1543 overturned this view in presenting the heliocentric model (Nussbaumer & Bieri 2009; Copernicus 1543). This was later confirmed observationally by Galileo in 1610 (Galilei 1610). Current models of cosmology view the Universe as a whole using a relativistic physical interpretation (Peebles 1993; Weinberg 1972). A founding concept in GR is that the physics of cosmology is independent of the reference frame (Einstein 1953).

The Hubble–Lemaitre Law is considered foundational in modern Cosmology (Weinberg 2008). Recessional velocity and the cosmological redshift appear as the only realistic explanation of the data when distances are measured from Earth. Furthermore, the theoretical works of Lemaitre and Friedmann showed that dynamic solutions to General Relativity were indeed favoured as the static solution was shown to be unstable (Lemaitre 1934; Friedmann 1922, 1924; Eddington 1954). The expanding universe is then consistent with both the theory and interpretation of the observational data.

Here an alternative interpretation of the redshift–distance data is presented. An assertion of the work presented here is that Earth-bound observation and measurement has led to interpretation of the redshift data as a cosmological redshift and expanding Universe.

A coordinate substitution so that distances increase toward Earth reveals a different physical interpretation of the data. Distance increases from the reference point that is at the beginning of the Universe. This is taken as the beginning of time where $t_0 = 0$ and $R = 0$. It is assumed that this time is taken after the formation of matter when the mass of the Universe is present. Using this reference frame allows that both time and distance increase along the same world line. Distance then increases toward Earth. Earth is placed at the distance of R_0, the radius of the Universe from the value of $R = 0$ at time zero. Using the distance scale allows the Pantheon+ SH0ES data to be fitted to a gravitational redshift as seen in Fig. 1.

2 ANALYSIS

Since Hubble first measured redshifts with distance that were interpreted as an expanding Universe, there has been considerable effort directed to measuring redshift–distance data in order to define the Hubble constant (Scolnic et al. 2022; Perlmutter et al. 1997; Riess et al. 1998). The avail-

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able Pantheon+ SH0ES data set has 1701 redshift–distance data points (Scolnic et al. 2022). Attributing the data to recessional velocity as a cosmological redshift and the Hubble–Lemaitre Law is a consequence of using Earth as the reference frame (Weinberg 1972, 2008).

The Pantheon+ SH0ES data (Scolnic et al. 2022) when plotted traditionally as luminosity distance (D) versus redshift z follows a logarithmic relationship:

$$\frac{d\log z}{d\log D} = 1, \tag{1}$$

where z is the redshift and D the luminosity distance. This is the Hubble–Lemaitre Law.

Making a coordinate substitution with the early Universe as the reference frame beginning so that R increases toward Earth yields:

$$\frac{d\log z}{d\log R} = -1, \tag{2}$$

where R is the distance from the origin of the universe at a given R_0 (and $D \sim 1.0 \times 10^{26}$ m). This is assumed to be the region where matter has been created in the big bang and the mass of the Universe exists (Lineweaver & Davis 2005). This then determines that the distance, R, measured in this way is the inverse of the luminosity distance D. This must be the case in order that both interpretations fit. Distances increasing from Earth give the Hubble expanding Universe while the interpretation with distances increasing toward Earth yields the gravitational interpretation developed here.

Equation (2) shows an inverse relation between z and R such that

$$z \sim 1/R. \tag{3}$$

Equation (3) is indicative of a Newtonian gravitational redshift where the gravitational potential $\phi_g = z \sim 1/R$. The fit to the Pantheon+ data is shown in Fig. 1 for the given values of R_0 and M.

Figure 1 shows the decreasing redshift with increasing distance when the distances R are measured from the beginning of time in the early Universe. Dimensional analysis determines that the radius R is defined as R_0^2/D, where R_0 is the radius of the Universe (1.0×10^{26} m) and D is the luminosity distance. The data at low redshift ($z < 0.1$) is fitted with a mass of 1.105×10^{53} kg. This is in close agreement with recent estimates of the mass of the known Universe at 1.19×10^{53} kg (Gaztañaga 2023). The data show redshifts that are lower than expected than the Newtonian curve for $z > 0.1$. This is seen in Fig. 2 where the residuals systematically increase (negatively) from the fit curve for $z > 0.1$. The Newtonian gravitational redshifts are valid for the limiting case of low field as observed. The data should tend to the relativistic redshifts at higher values. However, relativistic redshifts increase away from the Newtonian form at higher z, tending toward very large values at the Schwarzschild radius (Weinberg 1972). This suggests that there is another physics occurring at high z as discussed below.

Figures 3(a) and 3(b) show the histograms of the residuals plotted as both change in redshift (from the gravitational fit of Figs 1 and 2) plotted against the measured number of SNe Ia and Cepheids. Fig. 3(b) shows this data interpreted as velocities. Here it is assumed that the difference in redshift from the gravitational curve is a velocity. The curve fit is

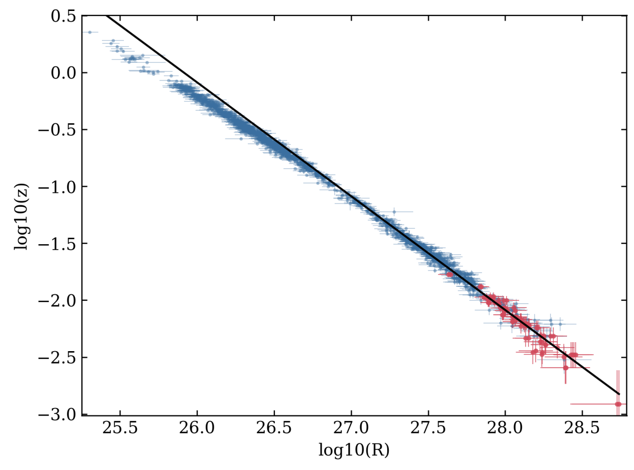

Figure 1. $\log_{10}(z)$ versus $\log_{10}(R)$ for the Pantheon+SH0ES Type Ia supernova sample ($N = 1701$), with $R \equiv R_0^2/d$, where d is the SH0ES luminosity distance recovered from the distance modulus ($d = 10^{(\mu+5)/5}$ pc). Error bars propagate the reported zHDERR (vertical) and MU_SH0ES_ERR_DIAG (horizontal, via $\sigma(\log_{10} R) = \sigma_\mu/5$) uncertainties. The solid black line is the weak-field Newtonian gravitational-redshift relation, $z = GM/(Rc^2)$, with R_0 held fixed at the full-sample best-fit value and M optimized by least squares against the $z < 0.1$ subset only ($n = 741$), then evaluated across the full sample shown. *Key*: blue – Hubble-flow SNe Ia ($n = 1624$); red – SH0ES Cepheid-host calibrator SNe ($n = 77$); solid black line – Newtonian gravitational-redshift fit, mass optimized on $z < 0.1$. *Fit parameters*: $R_0 = 1.032 \times 10^{26}$ m (fixed); $M = (1.105 \pm 0.004) \times 10^{53}$ kg (fitted on $z < 0.1$); $R^2 = 0.984$ on $z < 0.1$ subset, 0.987 on full sample.

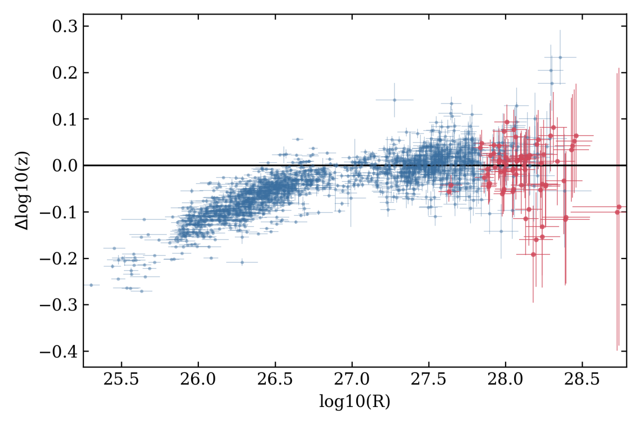

Figure 2. Fit residuals, $\Delta\log_{10}(z) = \log_{10}(z) - \log_{10}(z_{\rm model})$, plotted against $\log_{10}(R)$ for the full sample ($N = 1701$) using the $z < 0.1$-optimized mass from Fig. 1, with the same propagated error bars. The black horizontal line marks zero residual. *Key*: blue – Hubble-flow SNe Ia; red points – SH0ES Cepheid-host calibrator SNe; solid black line – zero-residual reference. *Residual statistics (full sample)*: mean ≈ -0.043; std ≈ 0.058 dex. The nonzero mean reflects that the mass was optimized on the $z < 0.1$ subset only, so residuals for the full sample are no longer centred on zero.

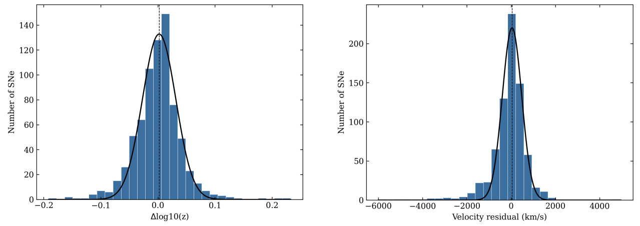

Figure 3. Residuals, $\Delta \log_{10}(z) = \log_{10}(z) - \log_{10}(z_{\text{model}})$, plotted against $\log_{10}(R)$ for the $z < 0.1$ subset ($n = 741$) using the $z < 0.1$-optimized fit. (a) Low-z residuals ($z < 0.1$) showing a Gaussian distribution around the gravitational fit. (b) Low-z residuals as velocities. Residuals were converted from $\log_{10}(z)$ space to an implied velocity via $\Delta z = z - z_{\text{model}}$ and the non-relativistic Doppler approximation $v = c\,\Delta z$, then histogrammed with Gaussian fits.

Gaussian, demonstrating that the velocities of the galaxies are random.

The alternative universe revealed by this new interpretation of the distances is static in size and internally dynamic, showing random galaxy velocities. It is postulated that the high-z redshifts deviate from the gravitational value due to the initial "escape velocity" of matter from the primitive universe. Matter is ejected into the Universe, resulting in a cosmological blue shift. This results in a blue shift contribution to the measured redshift values.

The deviation from the gravitational curve at high z may also be due to the breakdown of the point mass assumption used in the equations. The possibility exists that the early galaxies and cosmological objects may have velocities that contribute a blue shift to the measured signal. This correction would allow the data to be fitted and would be consistent with a Big-Bang type model of the early Universe.

Measurements other than redshift–distance have been made in order to verify the expanding Universe model (Weinberg 2008). Any alternative model presented must be consistent with other measurements of cosmic expansion. A major theoretical problem identified by Eddington and others is that the static solutions to the equations of GR appear to be unstable (Friedmann 1922, 1924; Eddington 1954; Lemaître & Eddington 1931; Lemaître 1931). This is a strong reason that the expanding Universe has been preferred over the static solution by theoreticians including Einstein (Weinberg 1972, 2008).

The Tolman surface brightness test has been suggested as a truly independent confirmation of the expanding Universe (Tolman 1934). Recent observations and their interpretation have been inconclusive. Lerner (2018) suggests that the data is consistent with a static Universe while the interpretation of Lubin & Sandage (2001) in a series of papers concludes that the expanding model is consistent with the data. Exponents of 2.6 and 3.4 were determined compared to the predicted value of 4 for an expanding Universe. The interpretation of the data by Lubin & Sandage (2001) uses several corrections to the data to obtain the reported values.

The cosmic microwave background (CMB) data does not preclude the static sized universe. The reference frame used here begins after the formation of matter. A modified Big-Bang model that generates matter is responsible for the CMB. The CMB does not preclude the model presented here. Baryonic acoustic oscillations are currently used to constrain the cosmological parameters that provide further insight into the nature of dark energy (Peebles 1980). The alternative model presented in the current work does not require dark energy. Future work will develop a relativistic model of the BAO power spectrum using a relativistic gravitational approach (Peebles 1980; Dodelson 2003).

Blondin et al. (2008) have interpreted the spectral broadening of 13 high redshift Type Ia supernovae as time dilation. The $1/(1+z)$ scaling of the aging rate of the SNe Ia is interpreted as confirmation of the expanding Universe, and they conclude that models without time dilation are unambiguously excluded. The gravitational model presented here must include time dilation in the strong fields responsible for the high redshift data. It is concluded that none of the independent tests of the expanding Universe rule out the static size, dynamic model presented.

Importantly, there are several issues with the Hubble–Lemaitre expanding Universe, the standard model, that are resolved in the gravitational model presented here. Dark energy and dark matter are not required by this interpretation. Stretched space is also not necessary as redshifts greater than 1 are feasible for gravitational redshifts. A feasible alternative to the "standard model of cosmology" (Peebles 1993) is revealed in the coordinate transformation used.

The interpretation of the redshift data presented here suggests three contributions to the thermodynamics of the Universe. An entropic "osmotic" pressure from the random Galaxy motion, a gravitational attraction between the Galaxies and a gravitational potential due to the presence of matter in the early Universe.

The "Cosmological constant" is then defined as the effective osmotic pressure due to the random Galaxy motion:

$$\Lambda = nkT, \tag{4}$$

where n is the number density of the Galaxies, k the Boltzmann constant and T the absolute temperature.

This interpretation gives a physical significance to the assumed outward pressure that was presented by Lemaitre without a physical basis (Lemaitre 1934; Lemaître 1931). However, rather than result in expansion as suggested by Lemaitre, this pressure leads to a steady state universe in that the gravitational attraction between galaxies is balanced by this osmotic term. This is indeed how Einstein first envisioned the Universe (Einstein 1917, 1953).

The nature of the origin of the Universe is not determined from this work. Several important questions remain regarding the generation of the static Universe. Further work is required to develop relativistic models of formation of the Universe in a modified Big-Bang model.

3 CONCLUSIONS

Interpretation of measured redshift–distance data using a distance scale that increases from the early Universe reveals an alternative to the expanding Universe. The Pantheon+ SH0ES redshift–distance data is shown to fit a Newtonian Gravitational redshift for low fields where $z < 0.1$. This alternative interpretation of the data suggests a Universe that is governed by gravity and static in size, with a random Gaussian distribution of Galaxy velocities. The alternative model of the Universe presented here is that originally posed by Einstein.

ACKNOWLEDGEMENTS

Claude AI was used in generating the figures and data fitting.

DATA AVAILABILITY

The Pantheon+ SH0ES data underlying this article are publicly available and were originally described by Scolnic et al. (2022).

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