CORRECTING SUPERNOVA LUMINOSITY FOR TIME DILATION IMPLIES NO DARK ENERGY

A PREPRINT

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ABSTRACT

Existing analysis of Type Ia supernova relies on the assumption that luminosity is not affected by time dilation. However, when luminosity is corrected for time dilation, the relationship between luminosity distance and redshift for Type Ia supernova becomes linear. This indicates that the expansion rate of the universe is not accelerating and there is no need for dark energy to explain observational data.

Keywords Cosmological Parameters · Dark Energy · Luminosity Distance

1 Introduction

TODO: Discuss Riess et al. [1998], Perlmutter et al. [1999], and Perlmutter and Schmidt [2003], as well as their nobel prize, summarized in Straumann and Zürich [2012].

Summarize dark energy. Emphasize that dark energy is a popular explanation for why distant supernova appear to be too far away.

Talk about the difficulty of curating supernova data, and summarize the work done by Betoule et al. [2014].

2 The dimming effects of redshift

The characteristics of redshift depend on the reason distant objects are redshifted. The dominant model is the big bang theory, where the farther away an object is from us, the more quickly it is moving away from us. Another theory is the tired light hypothesis, as described by Shao [2013], where distant objects are mostly stationary relative to us, but where the energy of light is lost as it travels through space. A feature of the tired light hypothesis is that since distant objects do not have a high relative velocity to us, they should not show time dilation. However, as shown by White et al. [2024], distant supernova do experience time dilation. Based on this, we reject the tired light hypothesis and assume the big bang model.

The magnitude measurements for Type Ia supernova goes through a long chain of data processing. The data used here was collected by the Dark Energy Survey Collaboration, as summarized in DES-Collaboration et al. [2024], while Vincenzi et al. [2024] describes the data processing pipeline in more detail. However, the data processing does not explicitly correct for either redshift or time dilation.

In the big bang model, there are two phenomena associated with redshift that we might expect to reduce the appearant magnitude of a Type Ia supernova. The first phenomenon is that the energy carried by a photon is inversely proportional to wavelength, so as redshift increases the wavelength of a photon, the energy decreases. The second phenomenon is that time dilation for objects moving quickly relative to our observational rest frame will reduce the rate at which photons are being emitted.

The supernova data collected by the DES Collaboration used a CCD camera, a photon counting device, as described by **?**. As noted by Kim et al. [1996], photometric measurements that depend on bolometers will need to be corrected for the reduced energy level of redshifted light, but with a photon counting device, this correction is not necessary.

However, time dilation also reduces the magnitude of light. Instead of changing the properties of individual photons, it reduces the count of photons by a factor of $\frac{1}{1+z}$. This phenomenon will not be addressed by the nuances of any measuring device, so it must be explicitly corrected.

3 Correcting magnitude for time dilation

Luminosity distance D_L, is the apparent distance of an object based on the observed luminosity, also known as the flux F. This does not take into account any movement of the observed object between the time when the light was emitted and the light is observed.

To derive the luminosity distance from these measurements, we start by computing the flux L. Magnitude M is defined on a logarithmic scale where magnitude 1 has 100 times the brightness of magnitude 6, leading to

$$F = \frac{1}{\sqrt[5]{100}^{M-1}}. \tag{1}$$

This is proportional to the number of photons detected by a telescope. We can find the corrected flux F^* by multiplying by $k(z)$, the redshift correction factor. Time dilation of quickly moving objects reduces the number of photons by a factor of $\frac{1}{1+z}$, so we have

$$\begin{aligned} F^* &= F \times k(z) \\ &= F(1+z). \end{aligned} \tag{2}$$

To compute the corrected magnitue M^*, we can solve

$$\begin{aligned} F^* &= \frac{1}{\sqrt[5]{100}^{M^*-1}} \\ M^* &= M - \frac{\ln{(z+1)}}{\ln{(\sqrt[5]{100})}}. \end{aligned} \tag{3}$$

4 Calibrated distance models

Calibrating a distance model involves finding a linear regression line for a model and then computing the value k required to make the regression model match a Hubble paramater. By arbitrary choice, we use $H_0 = 70\frac{km/s}{Mpsc}$.

The final units for distance will be in megaparsecs $Mpsc$. To find the recessional speed for a given redshift, we use $v = cz$ where c is the speed of light.

To compute a model, we use non-parametric regression via repeated means as described in Siegel [1982]. A comparison of both models is shown in Figure .

5 Disagreement with existing research

Previous studies use F instead of $F*$. According to Betoule et al. [2014],

$$D_L = k10^{\frac{M}{5}}. \tag{4}$$

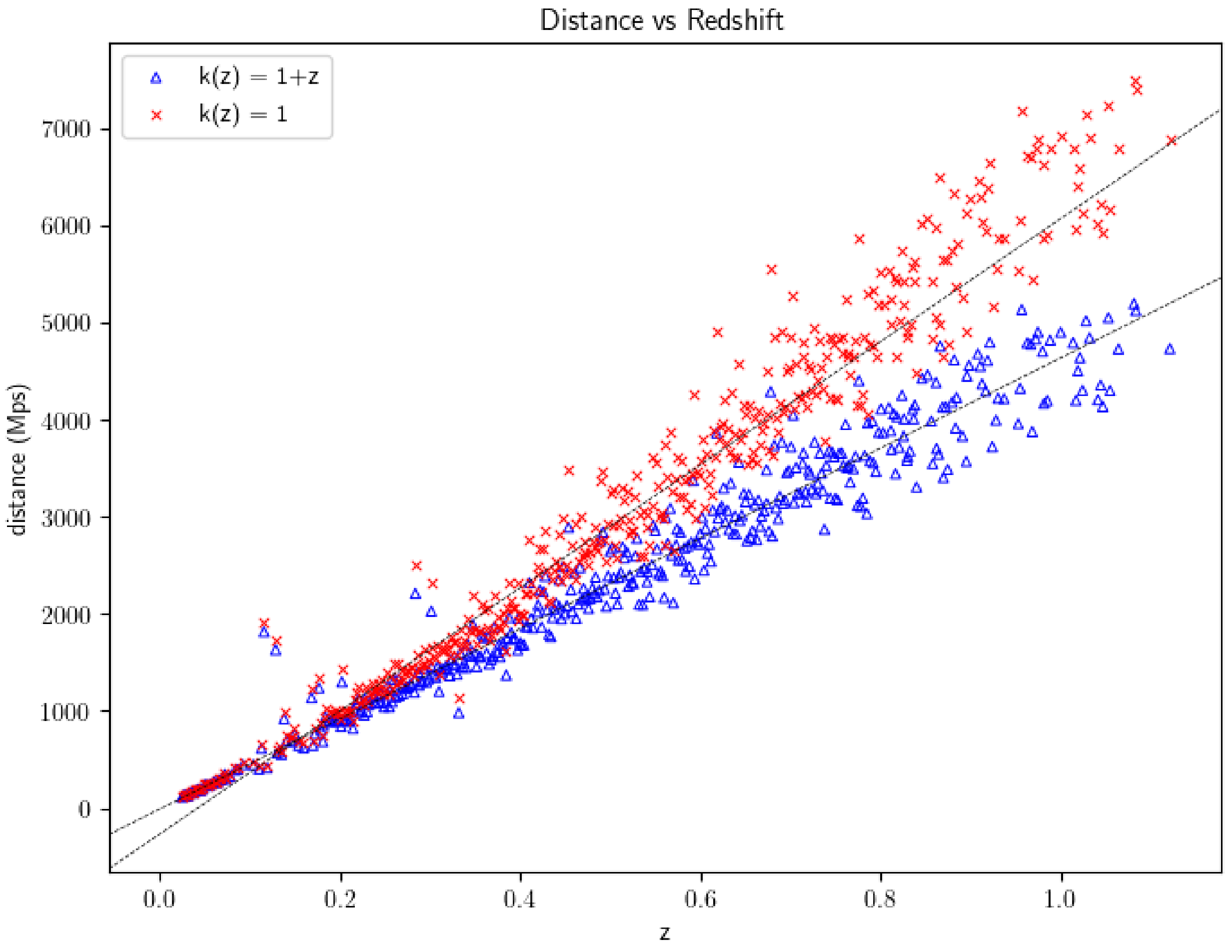

Figure 1: todo

6 Conclusions

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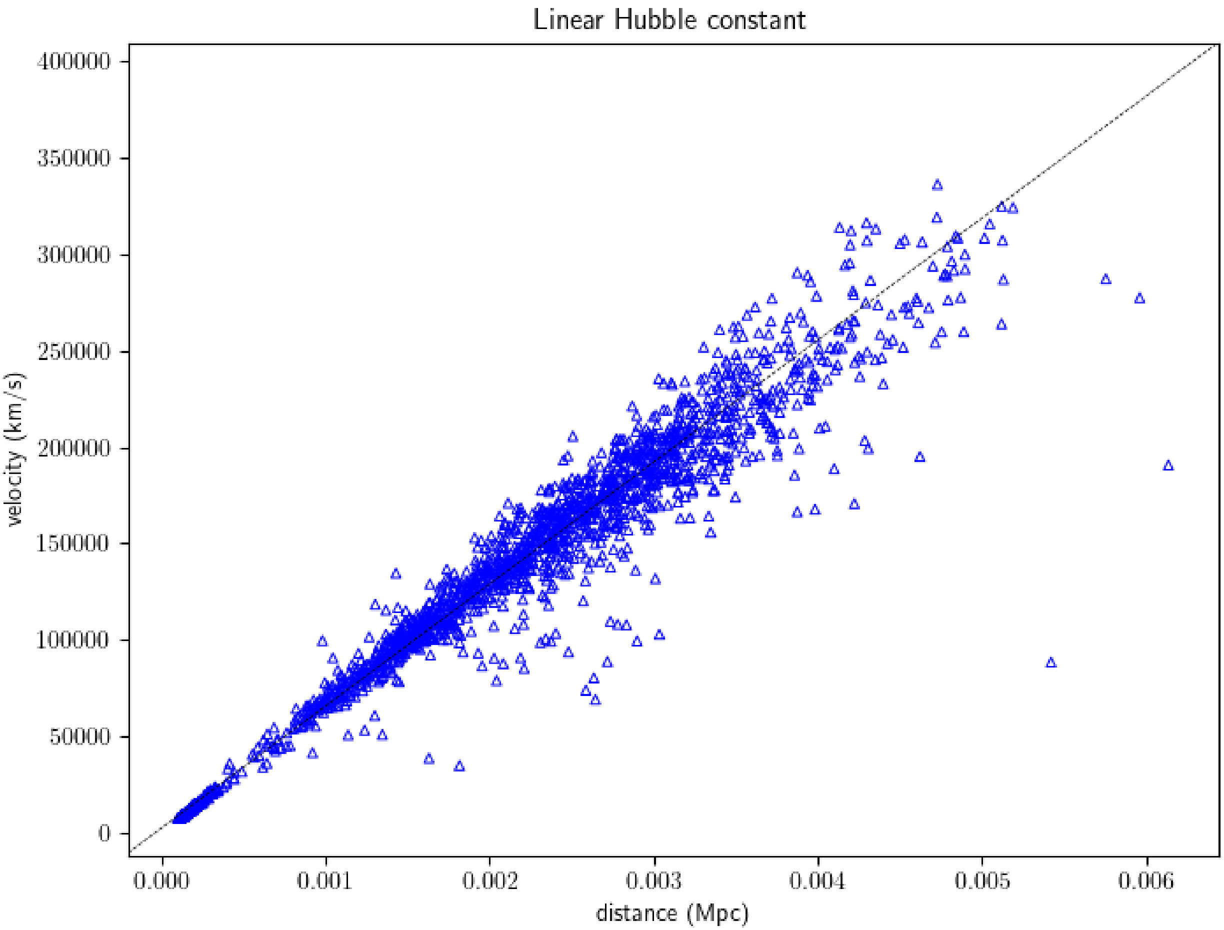

Figure 2: todo

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