Measuring the Hubble Constant with Twin Supernovae

Ayla Weitz[1, 2], Greg Aldering[2]

[1]University of California, Berkeley; [2]Lawrence Berkeley National Laboratory

Workforce Development & Education

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ABSTRACT

Type Ia supernovae (SNe Ia) have long been useful for cosmology, particularly in determining the Hubble constant (H_0), the expansion rate of the universe. Various methods have been used to measure H_0, and these techniques are becoming increasingly precise without converging. This contradiction is called the "Hubble Tension." In this work, we aim to use the Twins Embedding method of SNe Ia standardization to measure a value of H_0. We discuss the advantages Twins Embedding has over other commonly used standardization methods such as SALT2, and how we obtained and preprocessed SNe Ia spectra so they can be run through the Twins Embedding software.

BACKGROUND

- The Hubble constant, H_0, defines the universe's rate of expansion
- Hubble Tension — distant and nearby methods give disagreeing measurements of H_0

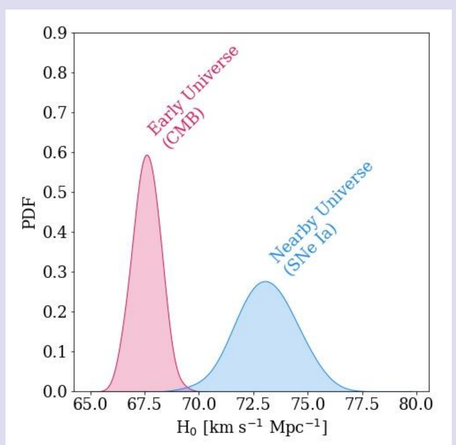
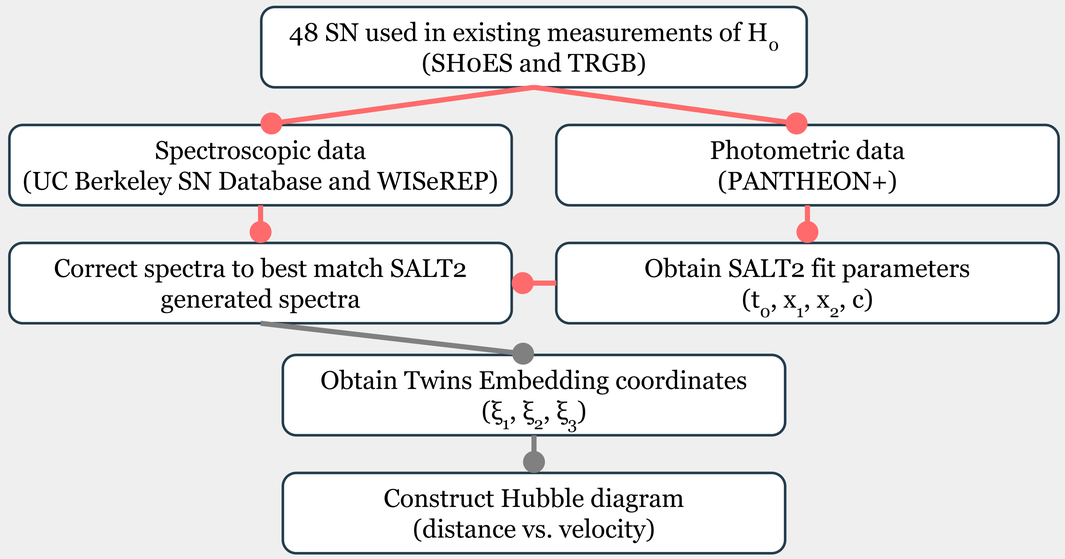


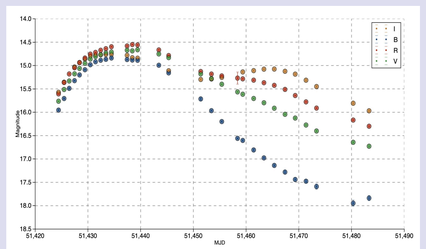
Figure 1: Marginal distribution of H_0 measurements from the Planck (red) and SH0ES (blue) teams. Planck measures H_0 indirectly using cosmic microwave background (CMB) radiation, and SH0ES measures it directly with SNe Ia. (Values taken from Valentino et. al 2021)

METHODS



TWINS EMBEDDING

Photometric



Spectroscopic

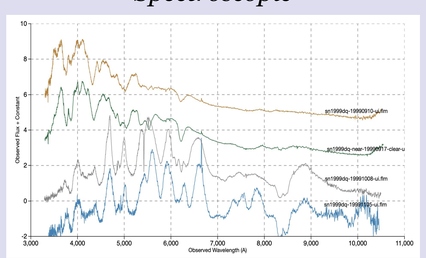


Figure 2: Photometric and spectroscopic data for 1999dq. (Figure taken from UC Berkeley SN Database)

- Method of SNe Ia standardization that uses spectroscopic instead of photometric data

Smaller systematics

- SN brightness less dependant on host galaxy properties (stellar mass and star formation rate)
- More accurate brightnesses give more accurate distances

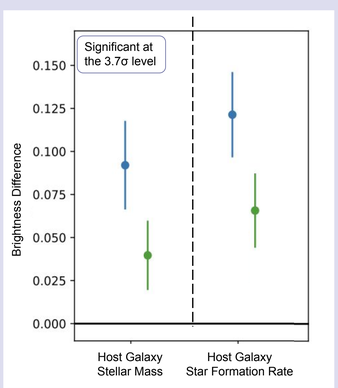


Figure 3: Brightness difference depending on the type of host galaxy for different methods of SNe Ia standardization. SALT2 (blue) and Twins Embedding (green). Twins standardization reduces the effect of host galaxy properties on SN brightness. (Modified figure from Boone et. al 2021)

Greater precision

- Standardizing using Twins Embedding has ~2.4 times as much weight in a cosmology analysis compared to other common standardization methods (Boone et. al 2021)
- SNe Ia occur once per 100 years per galaxy, so this more statistically powerful technique will allow us to obtain better H_0 measurements quicker

RESULTS

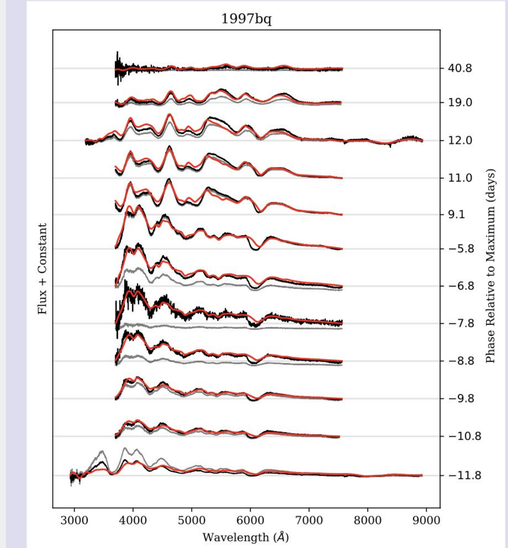


Figure 4: Scaled spectra for 1997bq (e.g. to account for clouds). Original spectrum (grey), scaled spectrum (black), and the SALT2 generated spectrum the scale factor was derived from (red).

CONCLUSIONS

We developed methods of correcting spectra using SALT2 parameters and methods to preprocess these data so they can be run through the Twins Embedding software. Next steps are to obtain Twins Embedding coordinates for these SNe Ia and use that to construct a Hubble diagram.

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