Light Curve Analysis of Type II SNe KSP-ZN7090

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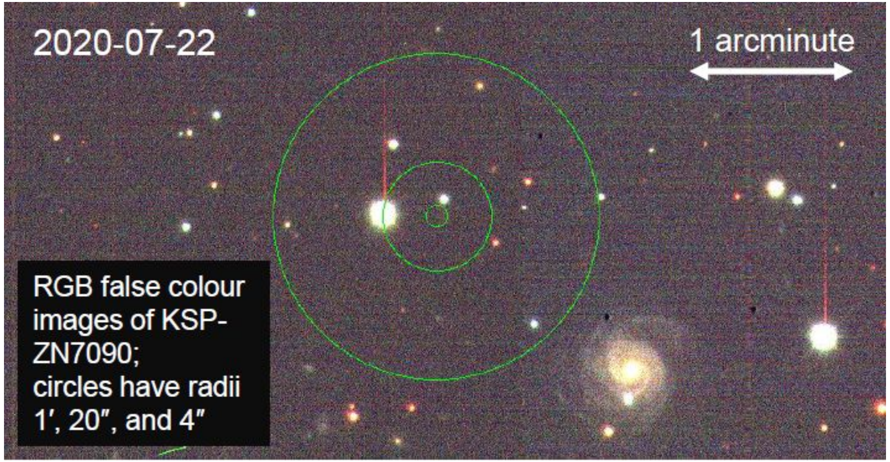
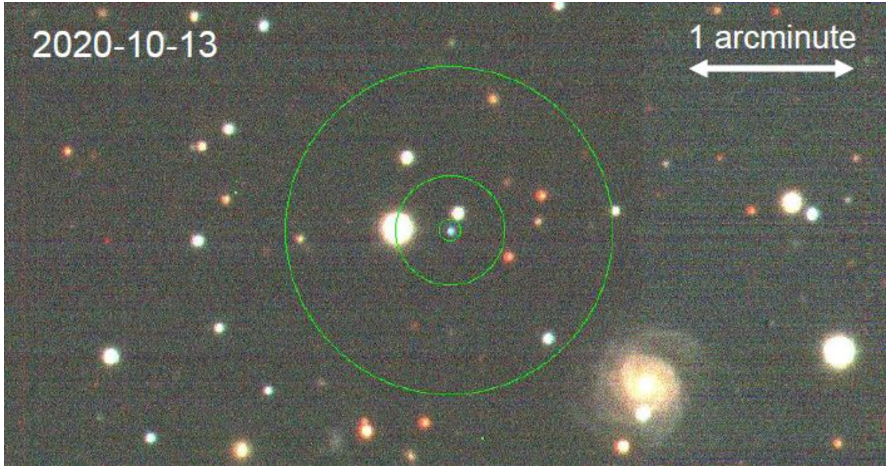
First Detection

- First detected by KMTNet on 2022-10-12 14:44 UTC
- Young Type II SNe detected 1 day after explosion
- Multiband observation (BVi)

$$\alpha = 21^h 31^m 3.05$$
$$\delta = -53^o 55' 49.91''$$



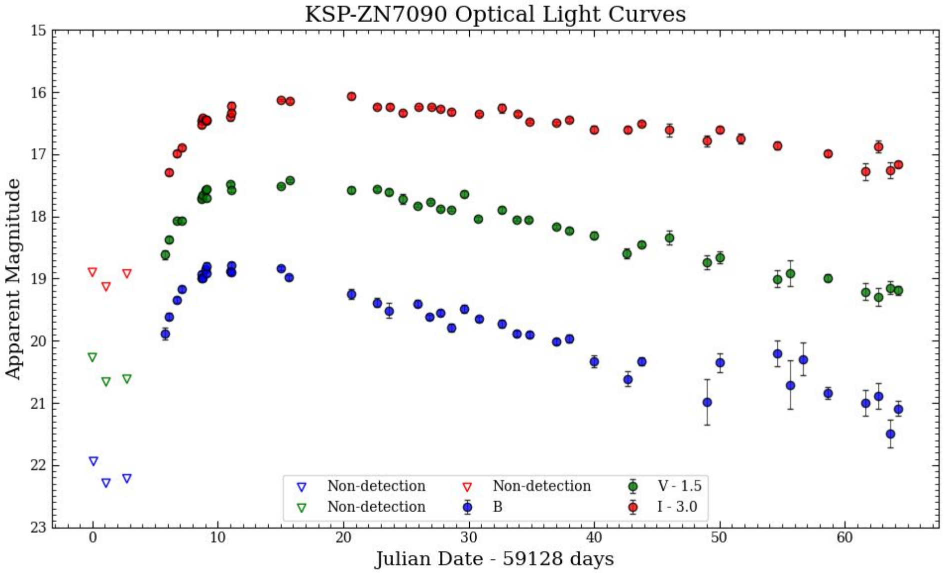


Korean Microlensing Telescope Network

- Network of three 1.6m wide field telescopes
- Locates in Australia, Chile and South Africa
- Provide 24hr of continuous sky survey

Mathew Leung
Photometry Work

- Image Subtraction
- PSF Photometry
- Discarding Bad Quality Images
- Light Curve Binning & Image Stacking
- Colour Corrections
- Extinction Correction



Creating Bolometric Light Curve for KSP-ZN7090

Bolometric light curves can be though as the light curves that account for all E&M radiation emitted at all wavelengths

Method: 1

- Direct integration of SED through multiple band photometry observations
- We only have 3 bands

Method: 2

- Apply bolometric corrections derived from well studied SNe
- We must properly classify and understand powering mechanism of ZN7090

Stage 1: Preliminary Analysis on Light Curves

Classifying our SN

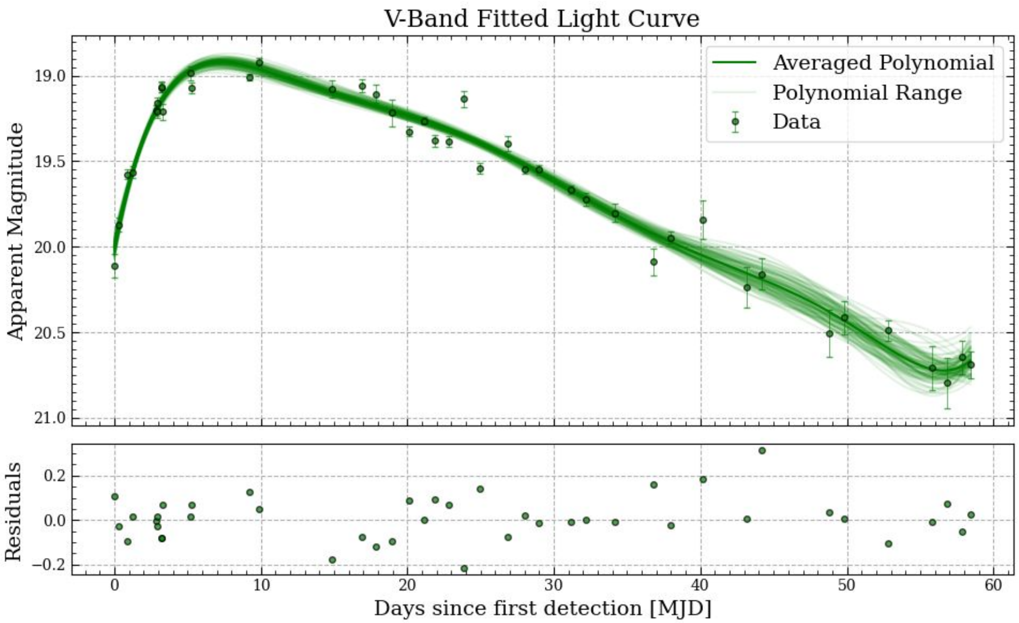
- A rough inspection on the host galaxy's spectrum indicated P-Cygni profile for H-alpha (Hint towards Type II SNe)
- Subdivision within Type II SNe
  - Type II-P
  - Type II-L
- Difference between division lies on the morphology of light curve

- Type II-L
  - Linear decline post peak
  - Decline rate is greater than 0.01 mag/day
- Type II-P
  - Plateau phase post peak
  - Attributed to hydrogen recombination on the ejecta

High Order Polynomial Monte-Carlo Fitting

- Constrain epoch of peak magnitude
- Fitted a polynomials of degree 7 for light curves
- We can see certain regions are more tightly constrained than others
- V-band decline rate:

$$\Delta m = 3.84 \pm 0.01 \frac{mag}{100\,day}$$



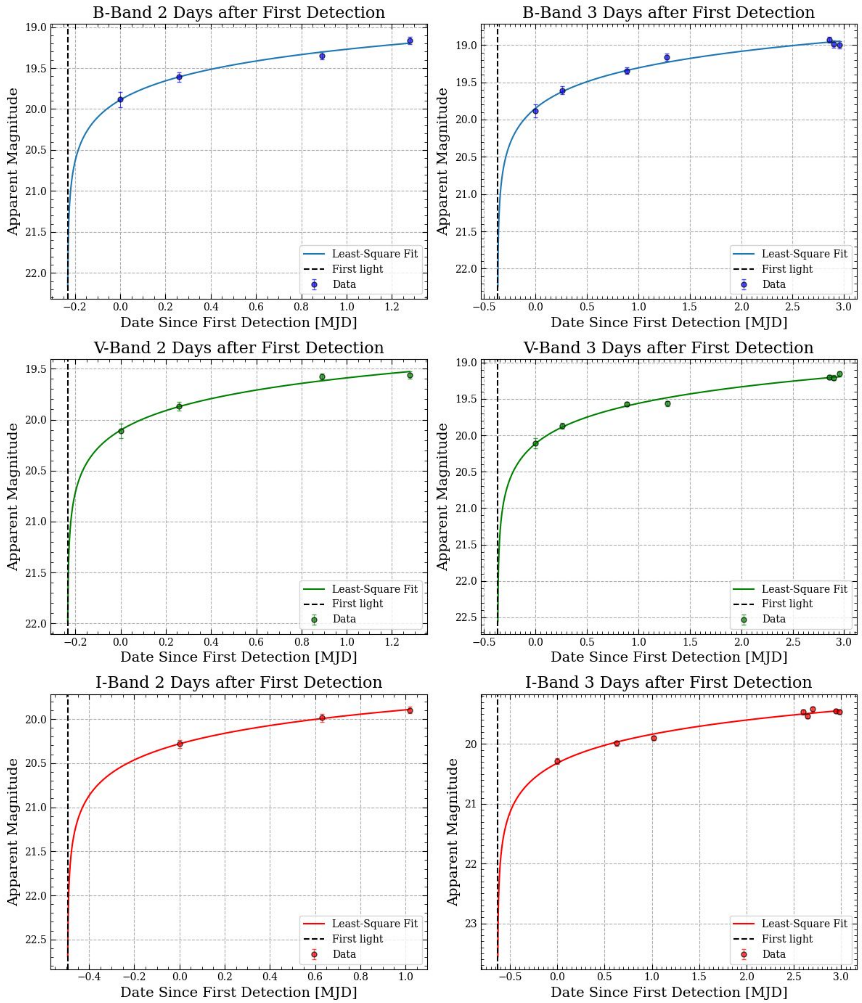
Light Curve Powering Mechanism

- Two main mechanisms could dominate a CCSNe
  - Shock breakout
  - Radioactive decay
- Difference lies on the light curve's rise time

Constrain Epoch of First Light

- Perform simultaneous power fitting on different models

$$f(t) = C_\lambda (t - t_0)^n$$



Stage 2: Applying Bolometric Corrections

Bolometric Corrections

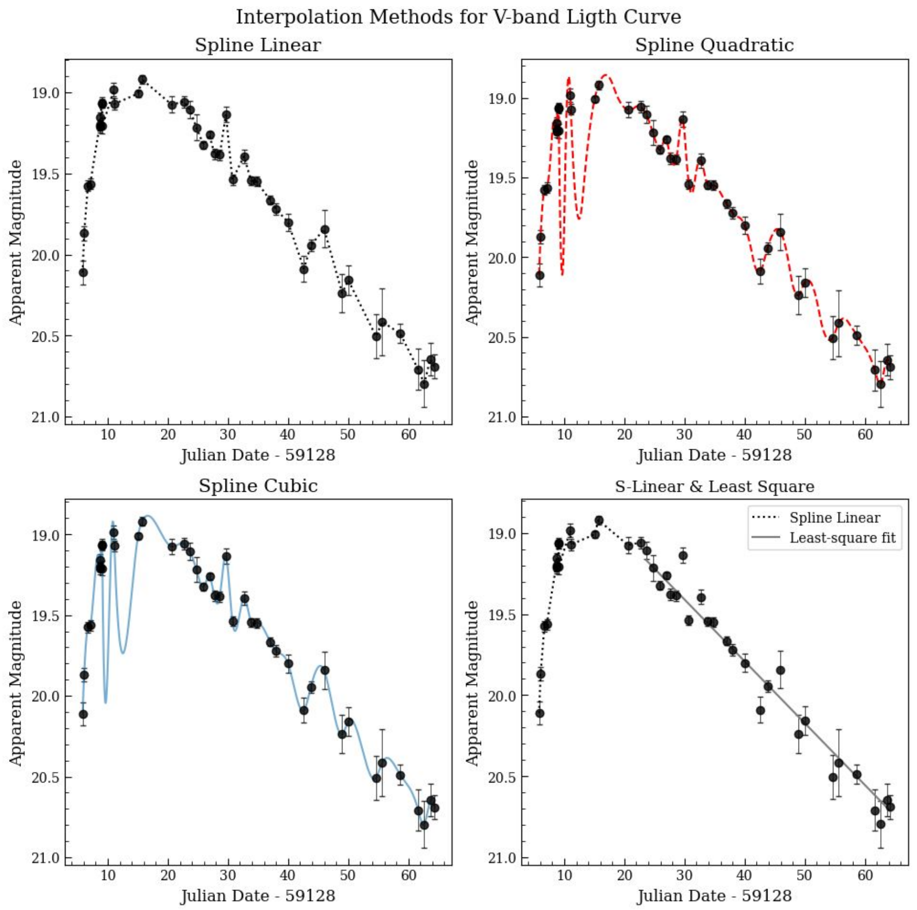
- Bolometric corrections are polynomial which provide a key for a conversion between bolometric magnitude and apparent magnitudes
- The methods for finding these correction vary between literature

$$BC_x = \Sigma_{k=0}^{n} c_k (m_x - m_y)^k \qquad BC_x = m_{bol} - m_x$$

Color

Interpolation of Optical Light Curves

- To apply the bolometric corrections we need all magnitudes to be in same epochs
- We chose spline linear interpolation



Bolometric Corrections Used

Martinez et al. 2022 , Colors: (B-V)

Layman et al. 2014, Colors: (B - V)

Layman et al. 2016, Colors: (B - i) (V-i)

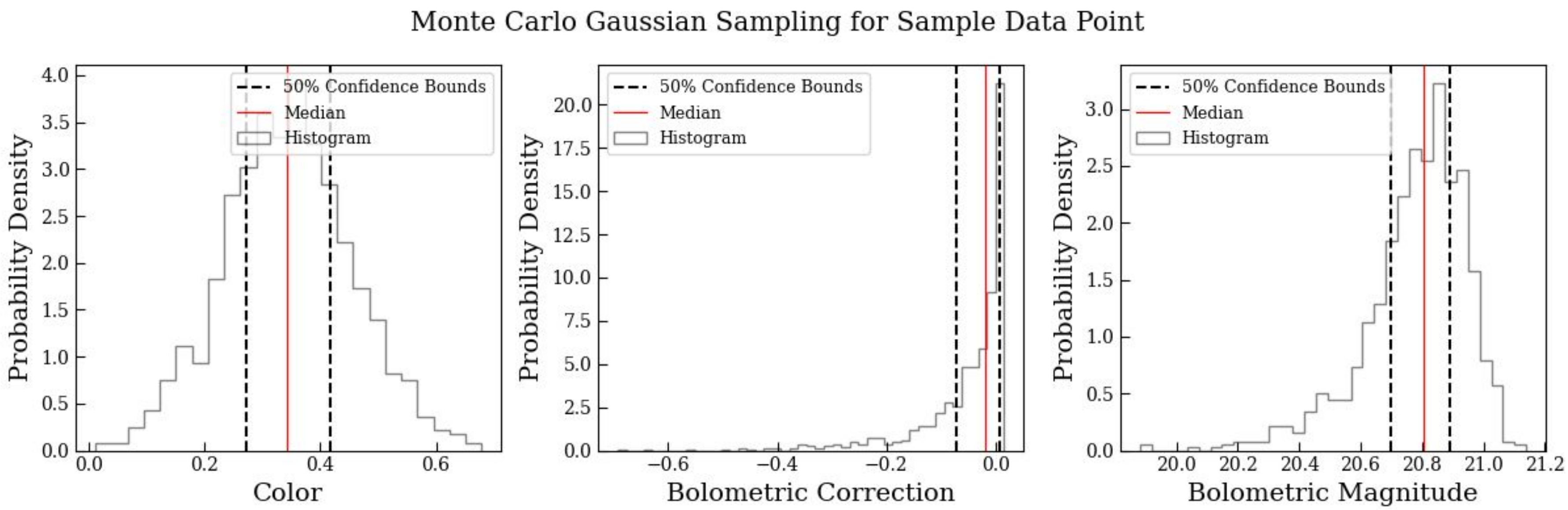
Table 1: Martinez et al. 2022 bolometric correction coefficients for polynomial of degree 4 specific to the shock cooling phase.

Color	Phase	Range	c_0	c_1	c_2	c_3	c_4	σ
B - V	Cooling	(-0.10,1.16)	-0.740	4.472	-9.637	9.075	-3.290	0.12

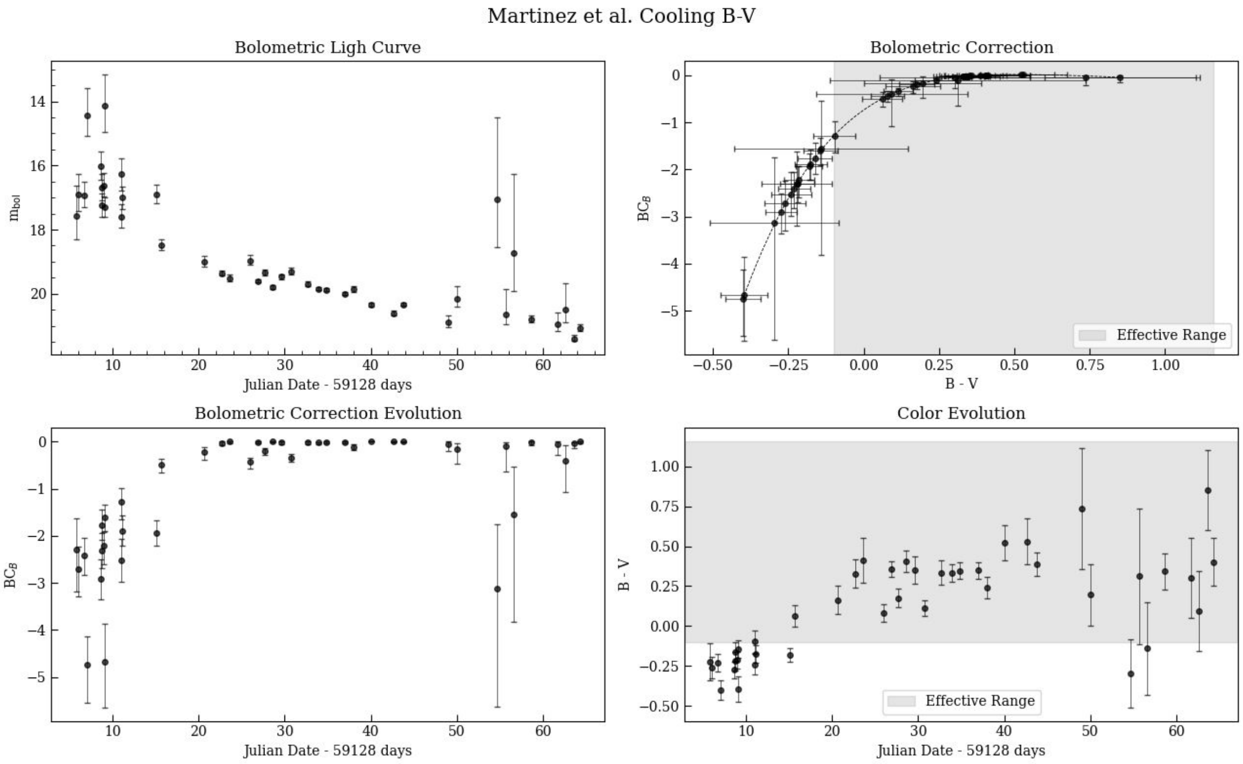
NOTE—BC $= \sum_{k=0}^{n} c_k\,(color)^k$ where color is taken from column 1. σ is the standard deviation about the fit.

Monte-Carlo Gaussian Sampling for Corrections

Sampled 1000 points from each magnitude data point assuming a normal distribution.



Martinez et al. Bolometric Light Curve



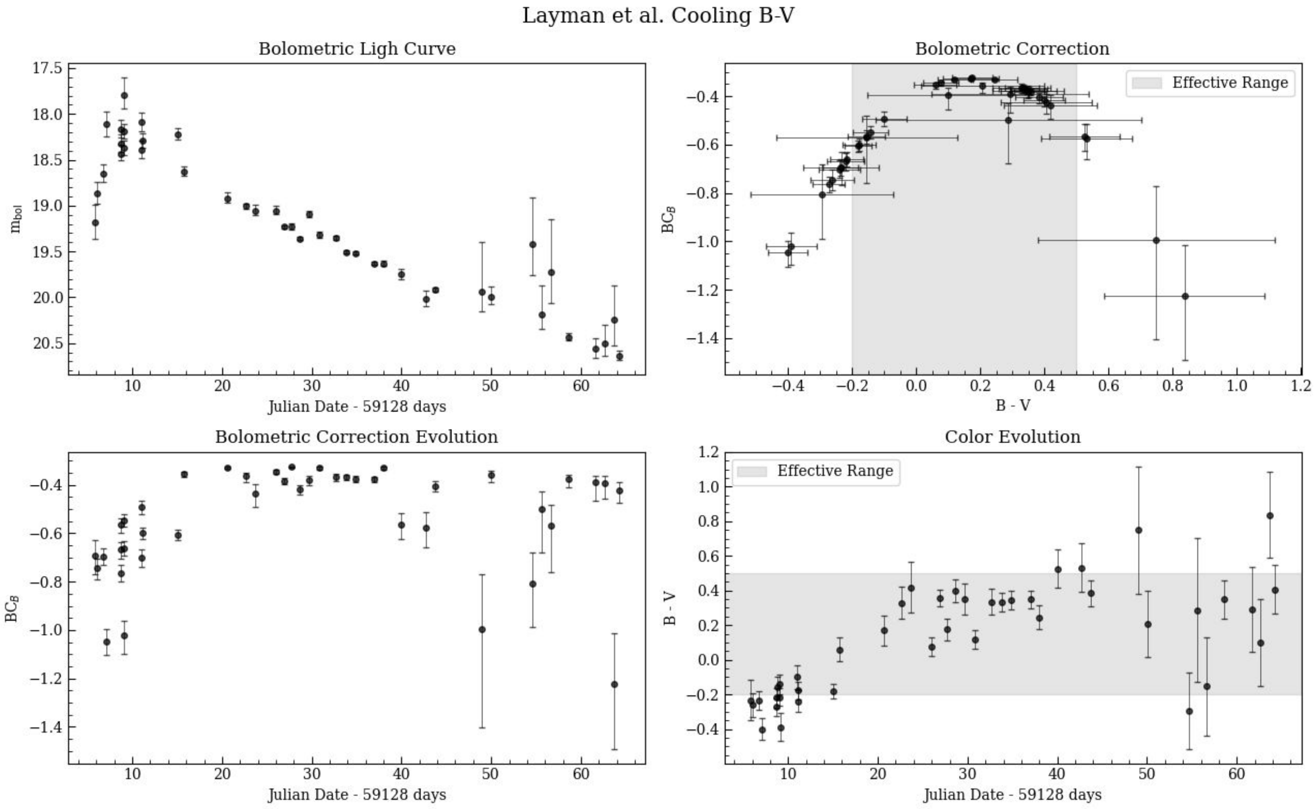
Layma et al. 2014 & 2016 Corrections

Layman provides a correction for a combination between Sloan and Johnson Cousin filters, and just Johnson magnitudes.

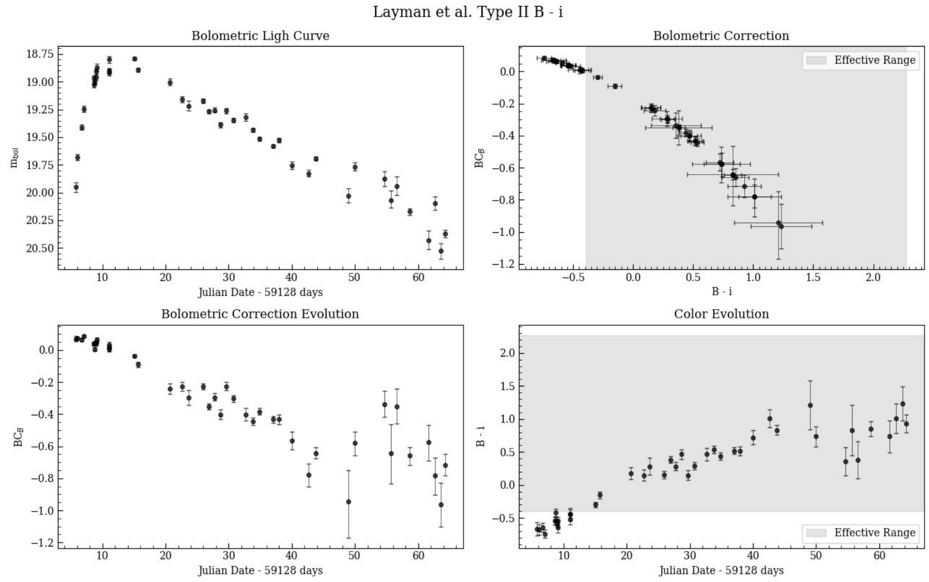
Table 3: Lyman, Bersier, James, Mazzali, et al. 2016b bolometric correction coefficients for polynomial of degree 2 specific to the shock cooling phase.

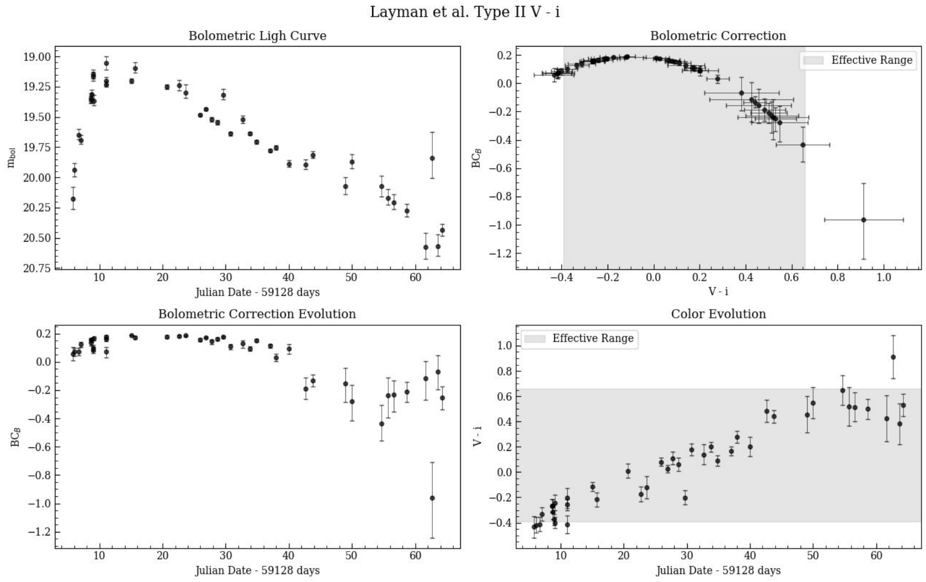
Color	Phase	Range	c_0	c_1	c_2	σ
B - V	Cooling	(-0.2,0.5)	-0.393	0.786	-2.124	0.089
B - i	–	(-0.392, 2.273)	-0.155	-0.450	-0.167	0.023
V - i	–	(-0.391, 0.658)	0.181	-0.212	-1.137	0.044

Layman et al. 2014



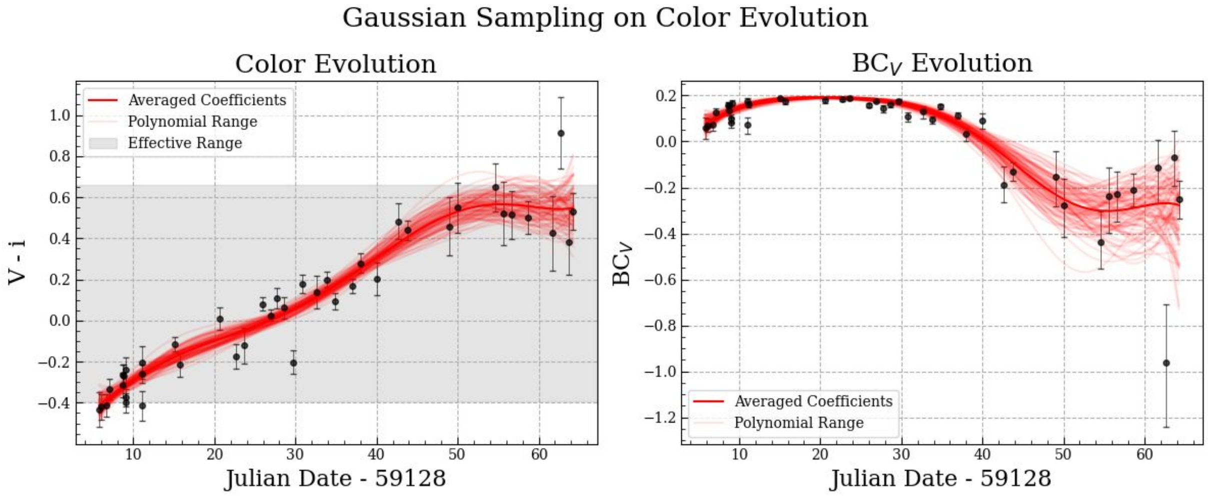
Layman et al. 2016





Smooth Color Evolution

- Color is a temperature indicator for a SNe
- All color evolutions plot indicate a transition from blue to red
  - Due to the cooling of the ejecta
- We expect this cooling to be a smooth monotonic function



Applying Simulated Color Evolution to Bolometric Correction

- Outlier bolometric magnitude in light curve has been ‘corrected’