Observational Study of Young Core Collapse Supernova KSP ZN7090

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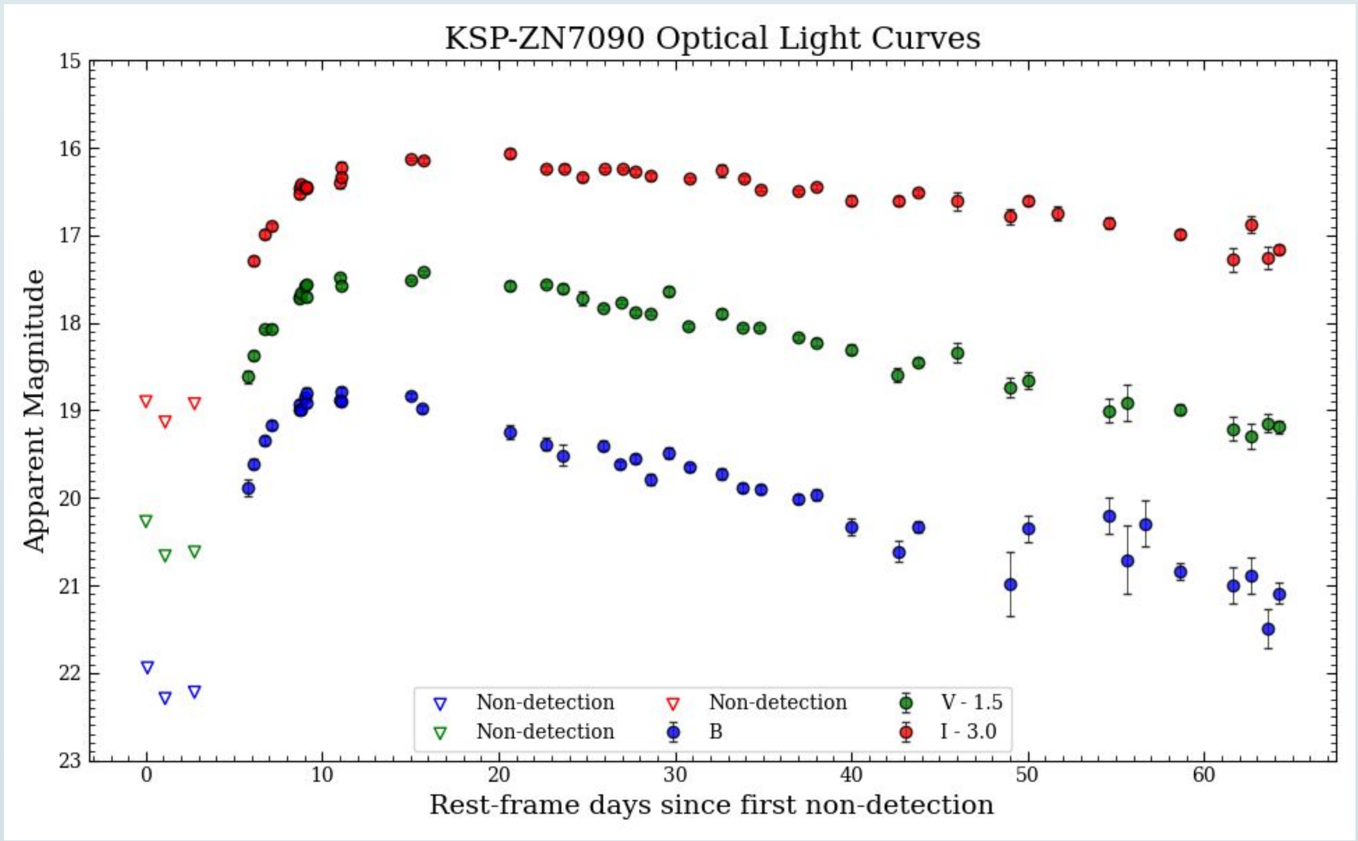
Abstract

We present multiband photometry and spectroscopy for a Type II Supernova (SN) ZN7090 which displays a steep post-peak decline in its V-band light curve. Using statistical methods to quantify the morphology of the light curve we classify KSP ZN7090 as a Type II core-collapse (CC) SN. This uncommon morphology is a product of H deficiency in the ejecta whose recombination causes the light curve to plateau. Furthermore, we constrain the rise time, and epoch of first light of the SN through multi-band simultaneous fitting which suggests that the power mechanism is shock cooling emission. We used analytical expression for the bolometric luminosity and photospheric temperature derived by Rabinak and Waxman 2011 to simultaneously fit the monochromatic flux densities of ZN7090. The results of the fit indicated that the model is not compatible with the observations as the reduced chi square is approximately 50.

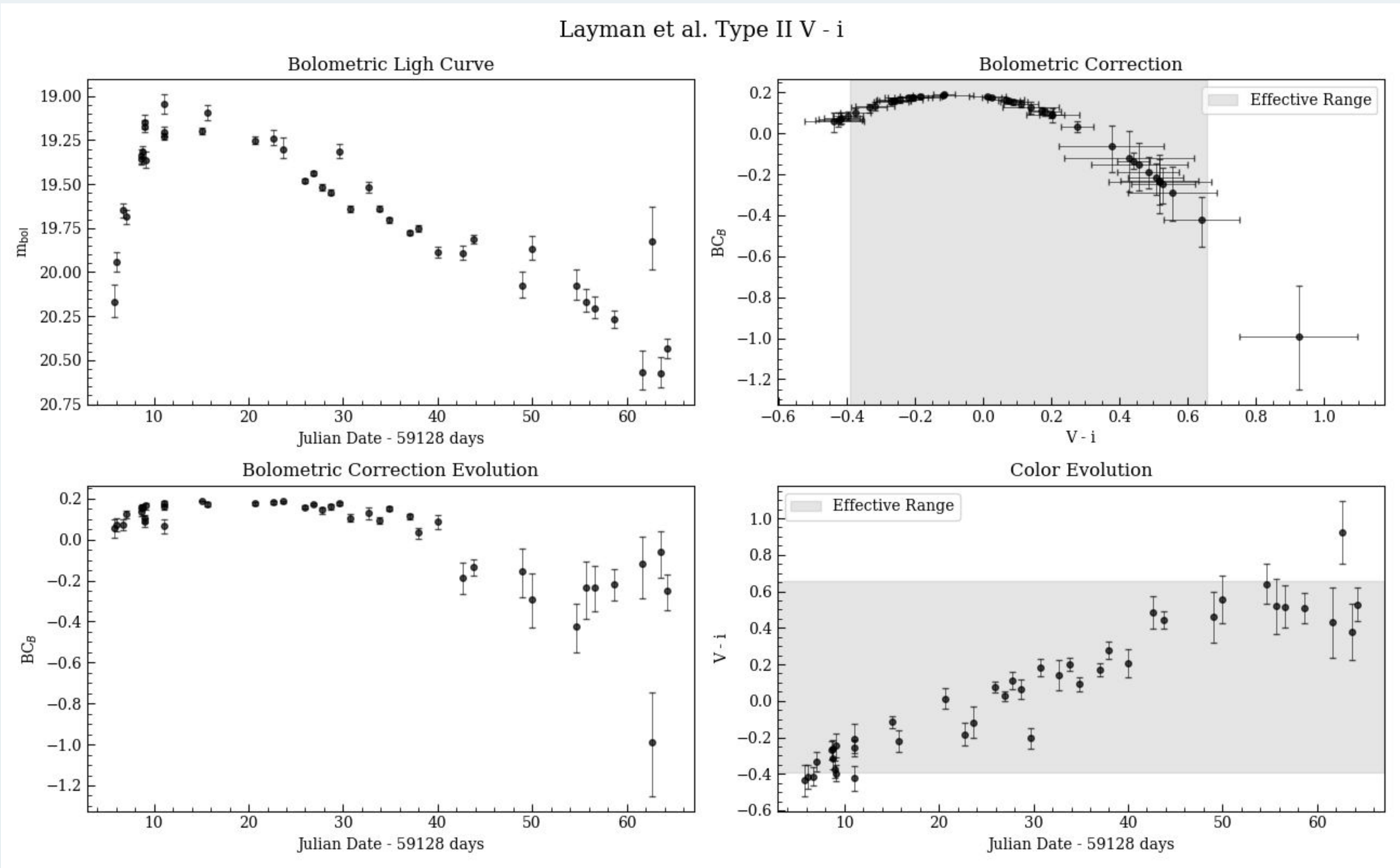
Optical Light Curve

Matthew Leung performed the image subtraction, PSF photometry, image stacking, color corrections and extinction corrections. From these processes we obtain the following monochromatic light curves.



Pseudo Bolometric Corrections

Bolometric light curves encapsulate the light from all emitted wavelengths, usually in the field of observational transients the observations range from the U to K bands. However, these observations tend to be rather expensive and difficult to conduct under the short time frame of the shock break out. For this reason, there has been several attempts at creating pseudo-bolometric corrections which can be applied to the color evolution of a SN in order to extract its bolometric magnitude.



Monochromatic Flux Density Light Curves

Some of the color data points are outside the effective range of the bolometric correction, which means these points are extrapolations. Therefore, another way we can perform pseudo-bolometric fitting with higher confidence is if we were to fit the flux density light curves simultaneously with the same explosion/progenitor parameters.

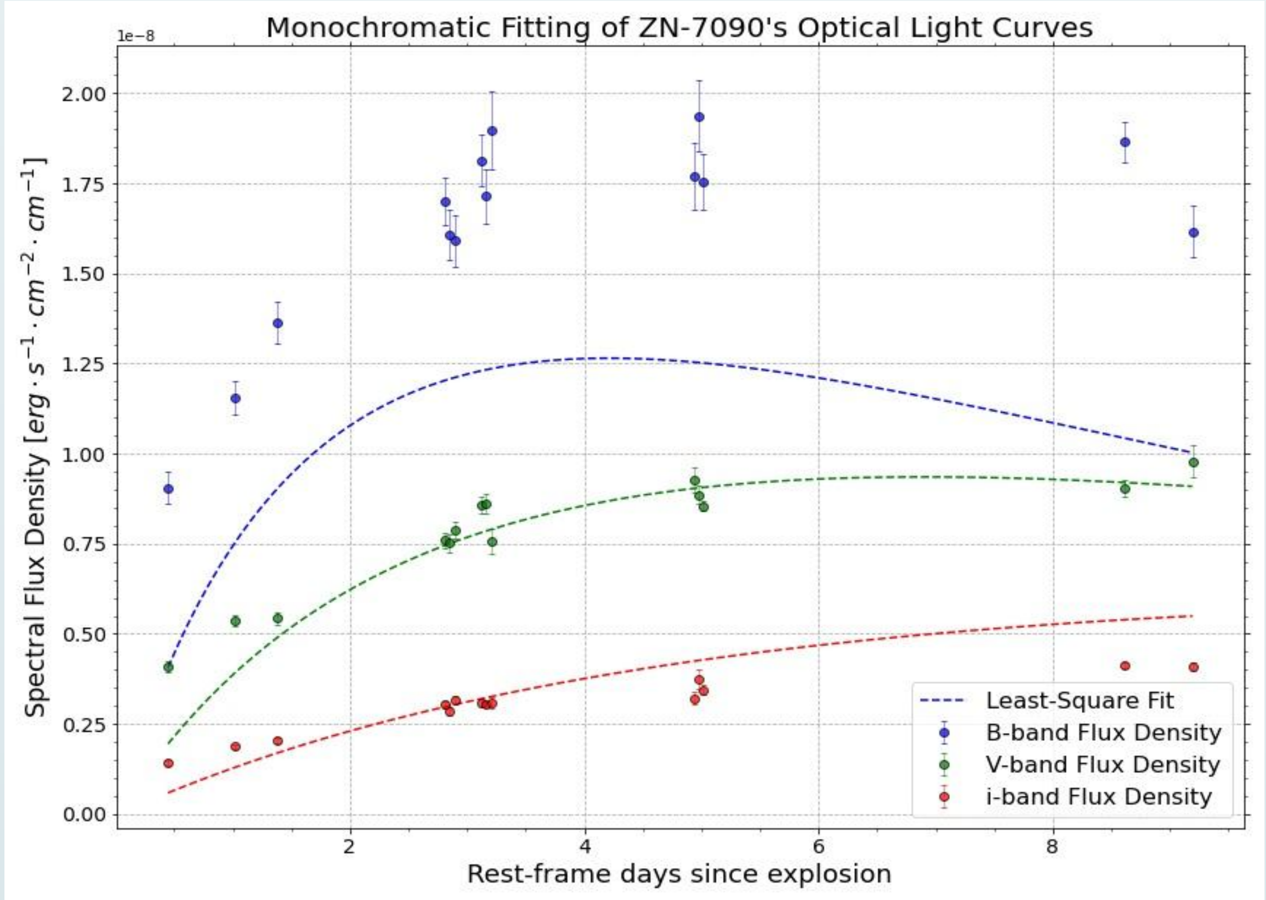
Explosion and Progenitor Parameters

From the apparent magnitudes we calculate the flux densities per unit wavelength. Using the analytical expressions for temperature and bolometric luminosity we can derive the corresponding monochromatic flux densities.

$$T_{ph} = 1.6 f_{\rho}^{-0.037} \frac{E_{51}^{0.027} R_{\star,13}^{1/4}}{(M/M_{\odot})^{0.054} \kappa_{0.34}^{0.28}} t_5^{-0.45}\, eV$$

$$L = 8.5 \times 10^{42} f^{-0.27} \frac{E_{51}^{0.92} R_{\star,13}}{(M/M_{\odot})^{0.84} \kappa_{0.34}^{0.92}} t_5^{-0.16}\, erg/s$$

The analytical expression only hold for the early stages of the light curve, particularly when the opacity is approximately constant and dominated by Thomson scattering (T > 0.7 eV). However, because we do not know the temperature, we will use other Type II CCSNe as reference which fit their light curves up until 11 days from the first light.



The results of the simultaneous fitting are physical and characteristic for red supergiant's. However, the reduced chi square for the fit is too high for us to claim our results hold any significance. We have observed the parameter space for 3 and 2 band fitting and the chi-square is not good enough. New models need to be investigated as well as further confirmation on treating the early stage of the SN as a blackbody.