Light Curve Analysis of a Young Type II-L Supernova KSP-ZN7090

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1. INTRODUCTION

Type II-L supernovae are a rare class of supernovae, accounting for <10% of all core-collapse supernovae (CC SNe). They behave in relatively unknown ways and are of great interest in understanding SNe explosion mechanics. We present the photometric observations of a Type II-L supernova KSP-ZN7090, which is one of the **earliest detected Type II-L SNe** to date. This SN was first observed less than 1 day after its explosion, on **October 12, 2020, 14:44 UTC** by the **KMTNet Supernova Program (KSP)**.

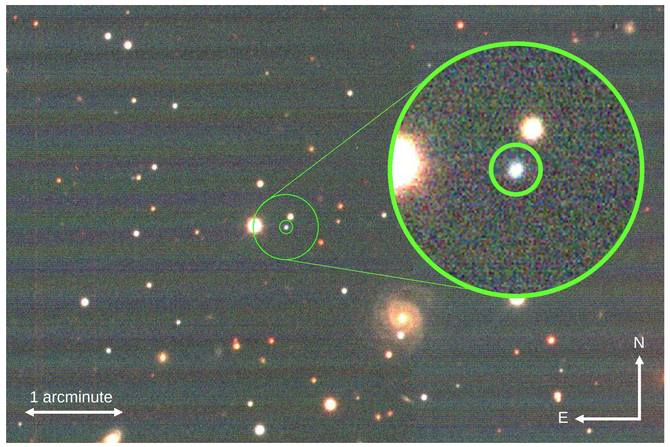

Figure 1 - False color RGB image of KSP-ZN7090 taken on October 21, 2020 near the *I* band peak. The inset (with radius of 20") shows a closer view of the SN, at (R.A., decl.) = (322h45m45.72s, -53°55'49.91").

2. OBSERVATIONS AND PHOTOMETRY

A 2°×2° field containing KSP-ZN7090 was observed by KMTNet from July 17, 2020 to December 11, 2020 in the *B*, *V*, and *I* bands. Key highlights of the photometry process are presented below:

- 13 *B*, 10 *V*, and 9 *I* band reference stars from the **AAVSO catalog** were used for zero point calibration
- PSF photometry was conducted using Moffat PSF fits
- **Image subtraction** was done on all images using HOTPANTS
- Non-detection limiting magnitudes were obtained by **stacking images** before the explosion using SWARP
- Later data points were binned with **inverse-variance weighting** to reduce spread due to moon brightness

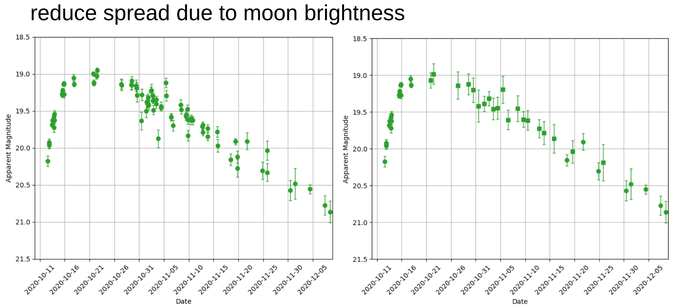

Figure 2 - KSP-ZN7090 *V* band uncorrected light curve without binning (left) and with binning (right). Binned points are shown with square markers.

3. FINAL LIGHT CURVES

Lastly, color and extinction corrections were made to the light curves. KMTNet's *B* band filters differed from the Johnson system used by AAVSO, and so a color correction procedure from Park et al. 2017 was used on the *B* band light curve. Using the R_V = 3.1 dust map from Schlafly & Finkbeiner (2011), we obtained an extinction of 0.091, 0.067, and 0.042 mag in the *B*, *V*, and *I* bands respectively.

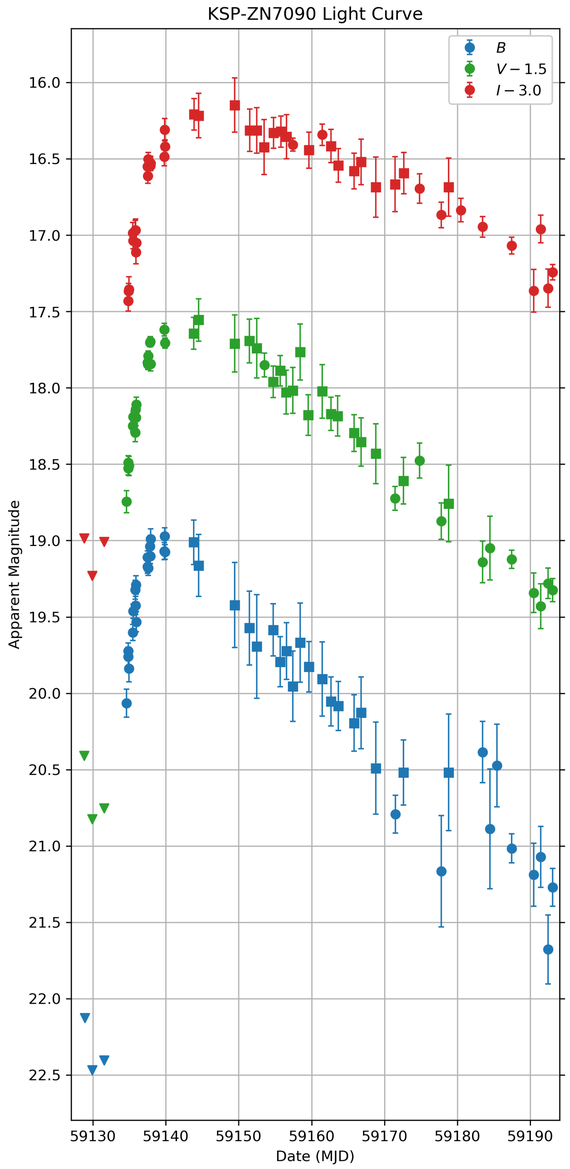

Figure 3 - KSP-ZN7090 corrected light curves in the *B*, *V*, and *I* bands. The downward triangle points are non-detection limiting magnitudes, the circular points are not binned, and the square points are binned.

4. PEAK EPOCH

To estimate the peak epoch, a **quartic polynomial** was fitted to the light curves of each band in the first **25 days** after the first observation. The peak in the *B*, *V*, and *I* bands occurred at 5.559 ± 0.486, 7.082 ± 0.795, and 9.517 ± 2.071 days respectively after the first observation. To estimate the errors, **Monte Carlo simulations** were performed, in which each data point was randomly shifted within its uncertainty range.

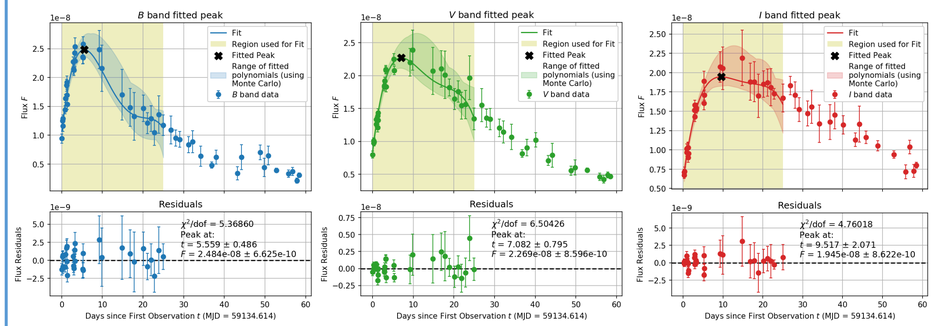

Figure 4 - Fitted peaks of the *B*, *V*, and *I* band light curves.

5. POWER LAW FITS TO EARLY EMISSION

A single power law was **fitted simultaneously** to the flux-normalized light curves of all 3 bands. The early part of the light curve, in the first 2 days after the first observation, was used for fitting. The resulting epoch of first light was **0.15 ± 0.05 days before the first observation**. KSP-ZN7090 has a relatively fast rise when compared to other Type II-L SNe such as SN 2013ej (Bose et al. 2015) and SN 2017ahn (Tartaglia et al. 2021), and also has a rapid decline rate compared to other Type II SNe (Faran et al. 2014).

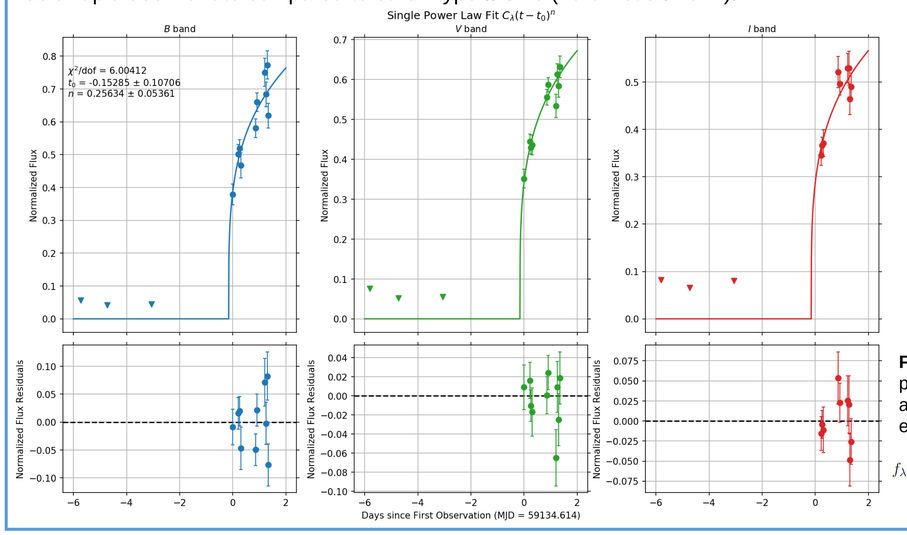

Figure 5 - Single power law fits according to the equation:

$$f_\lambda(t) = \begin{cases} 0 & \text{if } t < t_0 \\ C_\lambda (t - t_0)^n & \text{if } t \geq t_0 \end{cases}$$

6. CONCLUSION AND NEXT STEPS

We processed the light curve of KSP-ZN7090 and estimated some key parameters such as the epoch of first light and peak epoch. The next step would be to estimate other physical parameters such as ^{56}Ni mass and other properties of the progenitor. KSP-ZN7090 is a very unique SN and will hopefully help us better understand SN explosion and evolution.

7. REFERENCES

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