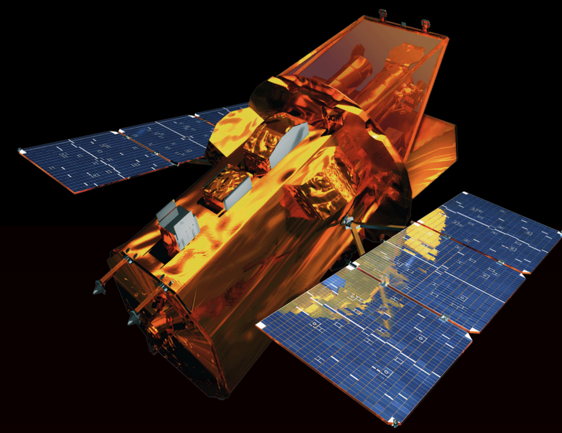
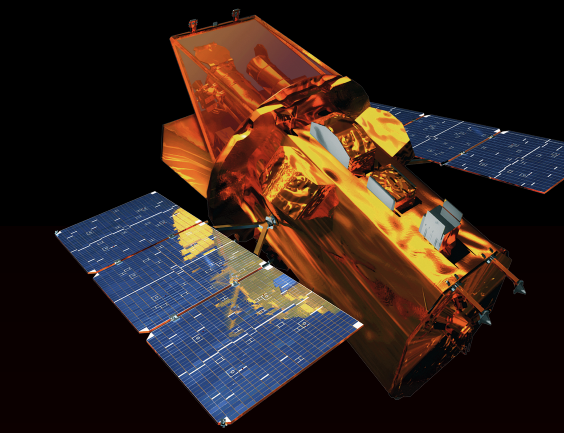


IIb or Not IIb: The Photometry of Type IIb Supernovae



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ABSTRACT

Type IIb supernovae (SN IIb) are a type of core-collapse supernova, meaning they result from the explosion of massive stars, and are classified by their spectra, which evolve from being dominated by Balmer hydrogen lines to helium lines. This unique spectral evolution is thought to be due to partial stripping of a hydrogen rich envelope from the event's progenitor. With the rapid increase of supernova detections in the past decade, more multi-wavelength photometric data is available than ever before, including data from the Swift Ultra Violet Optical Telescope (UVOT) in six ultraviolet and optical filters. Here we have compared and analyzed the photometric light curves of four type IIb supernovae, focusing on the UV and visible bands. This analysis will be able to aid astronomers in predicting the detectability of supernovae at large distances where the UV bands are redshifted to optical wavelengths, as well in the classification of type IIb supernovae.

TYPE IIB SUPERNOVAE

Supernovae are primarily categorized by their spectra. Type II supernovae have prominent Balmer Hydrogen Lines throughout their evolution, however type IIb supernovae are characterized by having spectra that are Hydrogen dominated in early time spectra and Helium dominated in late time spectra, evolving to resemble a type Ib supernova. These Supernovae are a are a type of core-collapse SN, resulting from the terminal explosions of massive star that leave behind a neutron star or black hole (Ben-Ami 2015). Their peculiar spectra are thought to be due to a partially stripped hydrogen rich envelope, either by stellar winds or Roche lobe overflow in a binary system . Their light curves (Figure 1) may consist of two peaks. The first is due to the supernova's shock wave reaching the progenitor's surface and the star proceeding to expand and cool. The second peak results from the radioactive decay of ^{56}Ni to ^{56}Co.

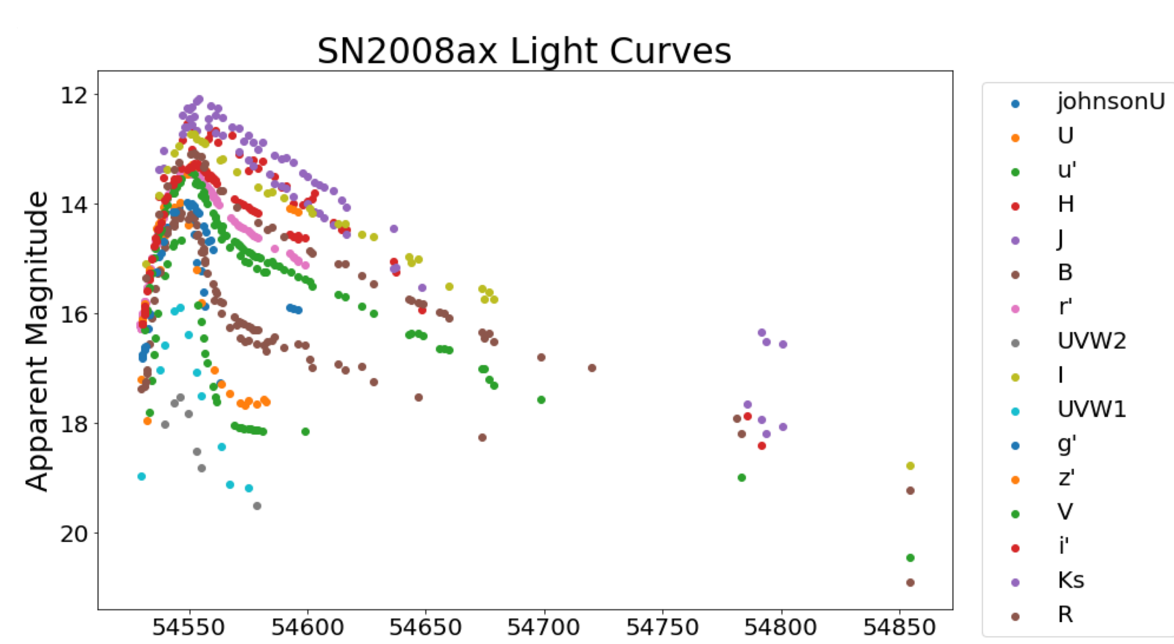

Figure 1: Light curves of Type IIb SN 2008ax plotting apparent magnitude as a function of Modified Julian Date.

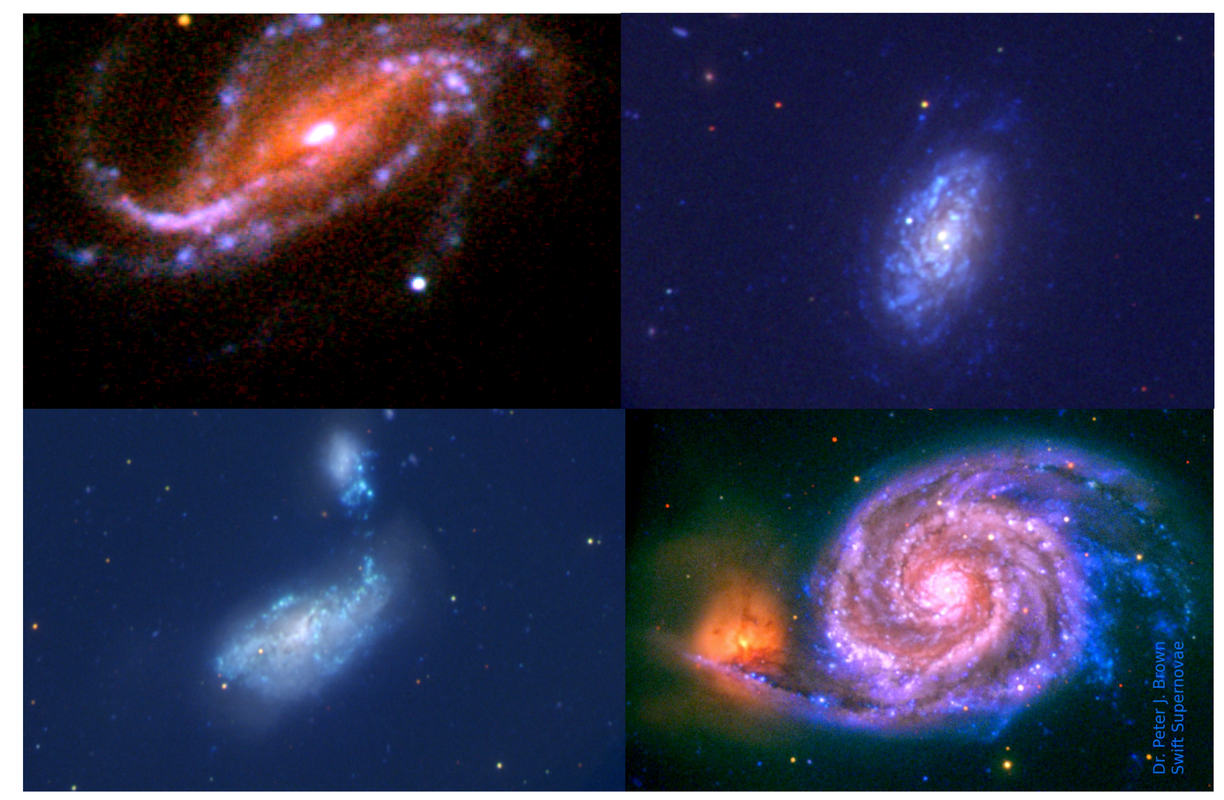

Figure 2: Images of host galaxies from the Swift Ultraviolet Optical Telescope. Top left: SN2013d in galaxy NGC5936 Top Right: SN2016gkg in galaxy NGC 613 Bottom Left: SN2011dh in galaxy M51 Bottom right: SN2008ax in galaxy NGC4490

LIGHT CURVE COMPARISON

Using data from the Swift Ultraviolet Optical Telescope (UVOT), as well as other surveys found in the open supernovae catalog, we were able to look at the light curves of four type IIb supernovae, SN2008ax, SN2011dh, SN2016gkg, and 2013df (Figure 2). UV/optical observations were made with the Ultraviolet Optical Telescope (Roming et al. 2005) onboard the Neil Gehrels Swift Observatory (Gehrels et al. 2004). Photometry was obtained from the Swift Optical Ultraviolet Supernova Archive (SOUSA; Brown et al. 2014). Comparing the light curves of these object we used a chi squared test to find the time stretch in the V band that would align the shapes of the curves best. The average time stretch was 1.0683, suggesting that the V-band light curves had almost identical shapes. By shifting each filter in SN2008ax up an amount equivalent to the difference between the maximums in each filter, the curves overlap and the nearly identical shapes of certain filters can easily be seen.

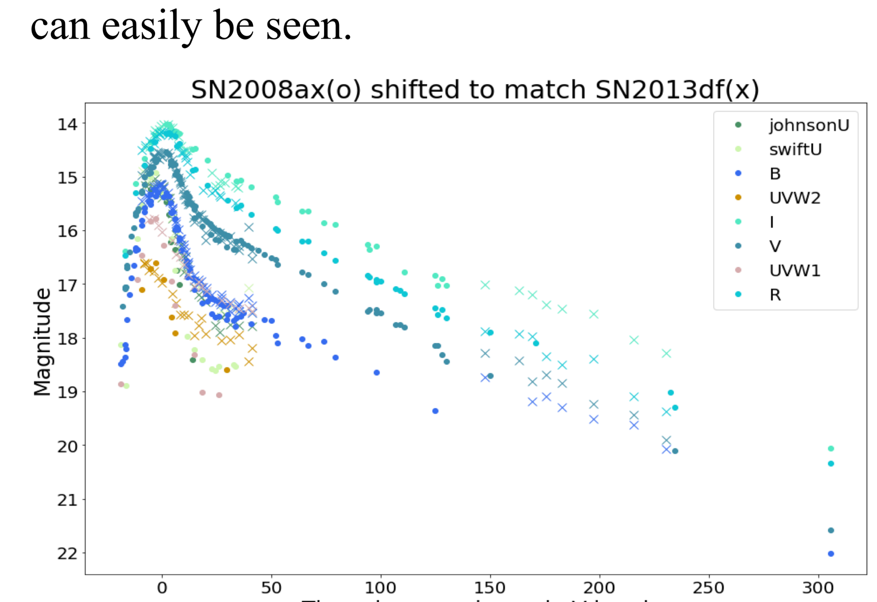

Figure 3. Light curves of SN2008ax (dots) shifted by a difference in each filter at maximum magnitude to overlap onto the light curves of SN2013df (x's). Data is interpolated at epochs of V filter data.

Object	Distance (Mpc)	Method	Source
SN2016gkg	26.4	Tully-Fisher	Arcavi (2017)
SN2013df	16.6	Cepheid	Freedman (2001)
SN2011dh	8.58	Tip of Red Giant Branch	McQuinn (2018)
SN2008ax	9.6	Avg. of Methods	Taubenberger (2011)

Figure 4: Distances of the four SN IIb taken from literature by various different methods

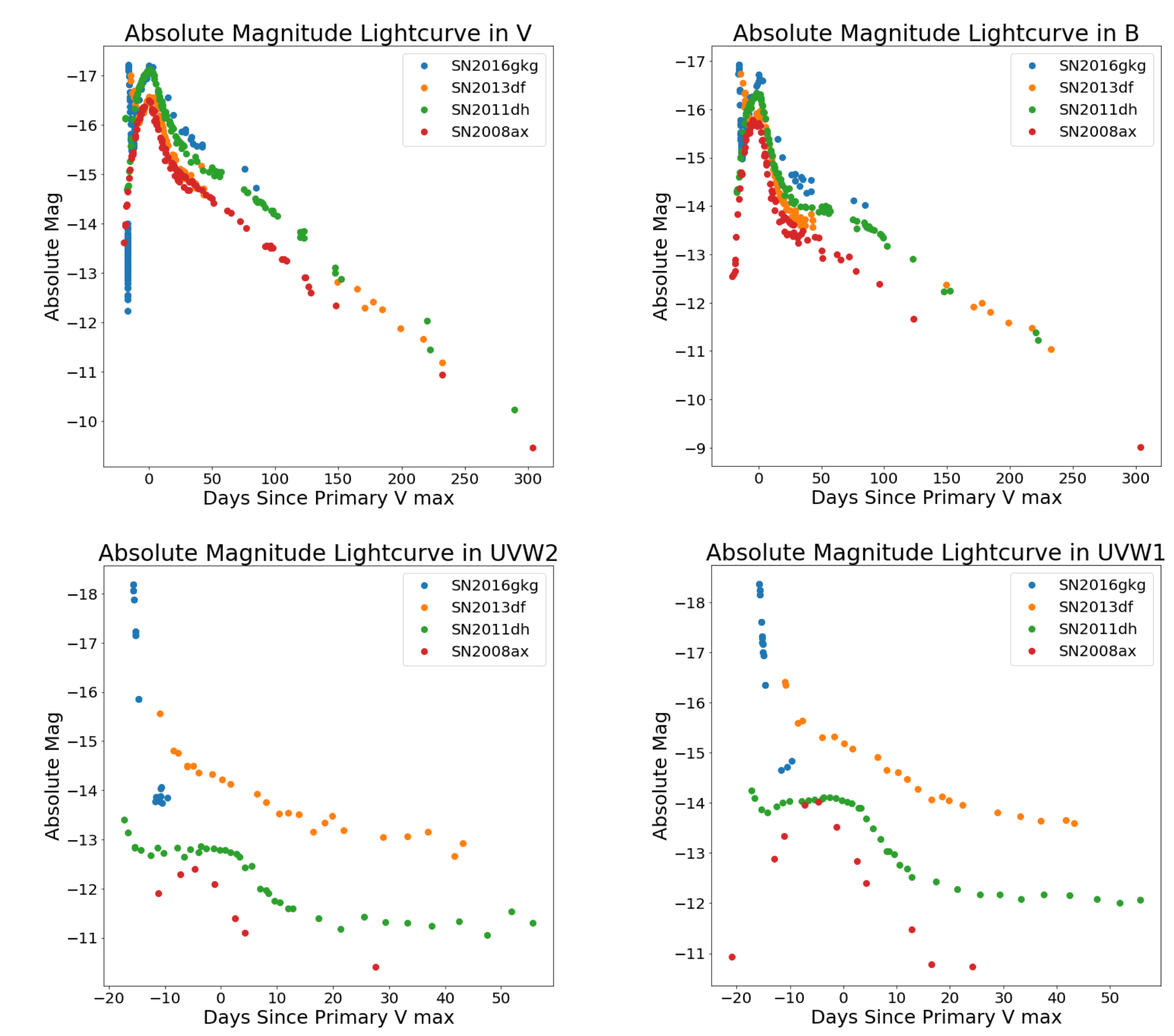

Figure 5: Absolute magnitude light curves of 4 SN IIb in filters V, B, UVW2, and UVW1. Days since primary V max on the x-axis is measured based on the common second peak of these objects due to ^{56}Ni decay.

ABSOLUTE MAGNITUDES

Using distances from literature (Figure 4), we plotted the absolute magnitude of the four objects in the V, B, UVW1, and UVW2 bands (Figure 5) as a function of days since the peak due to the decay of ^{56}Ni to ^{56}Co (primary peak). In the V and B bands, the difference between peak magnitudes is < 1 mag where the curves are all of similar shape in the rise but diverge slightly in the decline. This could be a product of the lack of correction for reddening. In the UVW1 and UVW2 filters, the peaks are unclear in SN2016gkg and SN2013df, however, the peaks in the other two objects are around the same magnitude. All the objects diverge greatly in the UV filters.

FUTURE WORK

The goal for the future is to be able to create a well sampled template in flux, time, and wavelength for type IIb supernovae. This template will serve as an aid to astronomers in the classification of type IIb supernovae, making it easier to answer the question, IIb or not IIb?

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