Optical photometry and spectroscopy of the Type Ibn supernova SN 2006jc until the onset of dust formation

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ABSTRACT

We present optical UBVRI photometric and spectroscopic data of the Type Ibn supernova SN 2006jc, until the onset of the dust-forming phase. The optical spectrum shows a blue continuum and is dominated by the presence of moderately narrow (velocity ~2500 km s\(^{-1}\)) He I emission lines superimposed over a relatively weak supernova spectrum. The helium lines are produced in a pre-existing He-rich circumstellar shell. The observed helium line fluxes indicate the circumstellar shell is dense, with a density of ~10\(^9\)–10\(^{10}\) cm\(^{-3}\). The helium mass in this shell is estimated to be ~0.07 M\(_{\odot}\). The optical light curves show a clear signature of dust formation, indicated by a sharp decrease in the magnitudes around day 50, accompanied by a reddening of the colours. The evolution of the optical light curves during the early phase and that of the uvoir bolometric light curve at all phases is reasonably similar to normal Ib/c supernovae.

Key words: circumstellar matter – supernovae: general – supernovae: individual: SN 2006jc.

1 INTRODUCTION

Core-collapse supernovae (CCSNe) signify the end of the most massive stars. They are categorized, spectroscopically, as Type II, IIb, Ib and Ic by the presence of strong hydrogen, helium and weak hydrogen, helium alone and no hydrogen or helium, respectively (see Filippenko 1997 for a review). Type IIn are those objects that show narrow hydrogen emission lines as a result of the interaction of the supernova ejecta with a dense circumstellar medium (CSM) (Schlegel 1990; Chugai & Danziger 1994). Wolf–Rayet stars, i.e. massive stars that have been stripped off their outer hydrogen and/or helium layers due to mass loss during the course of their evolution, are believed to be the progenitors of the stripped-envelope CCSNe (IIb, Ib, Ic). The possibility of yet another class of stripped-envelope CCSNe emerged with the detection of moderately narrow helium emission lines in SN 1999cq (Matheson et al. 2000), similar to the presence of narrow hydrogen lines in Type IIn. Matheson et al. suggested an interaction of the supernova ejecta with a dense CSM that had little or no hydrogen. SN 2002ao (Filippenko & Chornock 2002; Martin et al. 2002) was identified to be similar to SN 1999cq. The recent discovery of SN 2006jc with strong, moderately narrow helium emission lines, and weak hydrogen lines has added to the list of this new, interesting class of CCSNe, now designated as Ibn (Pastorello et al. 2008).

Supernova SN 2006jc was discovered by K. Itagaki, at a magnitude of 13.8, on 2006 October 9.75 UT on an unfiltered image (Nakano et al. 2006). The non-detection of this object on an image obtained on September 22 suggests the supernova was discovered shortly after explosion. Based on the presence of strong helium features in the early spectra, the event was classified to be of Type Ib (Fesen, Milisavljevic & Rudie 2006; Crotts et al. 2006). The similarity of SN 2006jc with SNe 1999cq and 2002ao was first noted by Benetti et al. (2006).

The progenitor of this supernova is believed to have experienced a luminous outburst, similar to those of luminous blue variables (LBVs) two years prior to the supernova event (Nakano et al. 2006; Pastorello et al. 2007). Multiwavelength observations of this supernova have shown it to be unique in many respects. Early Swift UVOT observations on 2006 October 13 by Brown, Immler & Modjaz (2006) indicate extremely blue UV-V colours. X-ray emission has also been observed by the Swift (X-ray Telescope) and the Chandra satellites (Immler et al. 2008). On the contrary, SN 2006jc was not detected in the early-time radio observation (Soderberg 2006). The X-ray emission and the UV excess are attributed to an interaction of the supernova ejecta with a shell of material deposited during the recent luminous outburst of the progenitor (Immler et al. 2008).

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The optical spectra (Foley et al. 2007; Pastorello et al. 2007) show a prominent blue continuum that lasts well into the onset of the nebular phase. Around 75 days since maximum, the steepness of the blue continuum had dropped, while the continuum in the red had brightened, with the overall spectrum taking a ‘U’ shape (Smith, Foley & Filippenko 2008). The red excess had disappeared by day 128. Interestingly, the optical light curves showed a sharp decline after day 50, while the near-infrared (NIR) luminosities brightened during the same epoch (Arkharov et al. 2006; Minezaki, Yoshii & Nomoto 2007; Smith et al. 2008). The NIR excess peaked around 80 days and persisted to past 200 days (Sakon et al. 2008; Di Carlo et al. 2008; Mattila et al. 2008). Smith et al., Di Carlo et al. and Mattila et al. attribute this NIR excess to the formation of a hot dust in an outward shock-formed cool dense shell, while Sakon et al. (2008), Nozawa et al. (2008) and Tomimaga et al. (2008) propose dust formation in the supernova ejecta.

We present in this paper the optical photometric and spectroscopic observations of SN 2006jc obtained with the 2-m Himalayan Chandra Telescope during 2006 October 14–2007 January 13.

2 OBSERVATIONS

Photometric monitoring of SN 2006jc in the UBVRI and I bands began on 2006 October 16 (JD 245 4025.45) and continued until 2007 January 13 (JD 245 4114.40), using the Himalaya Faint Object Spectrograph Camera (HFOSC). Photometric standard fields (Landolt 1992) PG0231+051 and PG0942−029 were observed on 2006 November 23 and the fields PG1047+003, PG0942−029 and PG1323−086 were observed on 2006 December 27 under photometric conditions. These were used to calibrate a sequence of secondary standards in the supernova field. The data reduction and photometry were done in the standard manner, using the various tasks available within IRAF. The observed data were bias-subtracted and flat-field-corrected, and cosmic-ray hits were removed. Aperture photometry was performed on the standard stars, using an aperture radius determined using the aperture growth curve, and were calibrated using the average colour terms and photometric zero-points determined for the individual nights. The UBVRI magnitudes of the secondary standards in the supernova field, calibrated and averaged over the two nights, are listed in Table 1. The secondary sequence is shown in Fig. 1 (marked by numbers). The magnitudes of the supernova and the local standards were estimated using the profile-fitting technique, using a fitting radius equal to the full width at half-maximum (FWHM) of the stellar profile. The difference between the aperture and profile-fitting magnitude (aperture correction) was obtained using the bright standards in the supernova field, and this correction was applied to the supernova magnitude. The calibration of the supernova magnitude to the standard system was done differentially with respect to the local standards.

Spectroscopic monitoring of SN 2006jc began on 2006 October 14 (JD 245 4023.47) and continued until 2006 December 14 (JD 245 4084.35). The log of spectroscopic observations is given in Table 2. The data reduction was carried out in the standard manner using the tasks available within IRAF. The data were bias-corrected, flat-fielded and the one-dimensional spectra extracted using the optimal extraction method. Spectra of FeAr and FeNe lamps were used for wavelength calibration. The instrumental response curves were obtained using spectrophotometric standards observed on the same night and the supernova spectra were brought to a relative flux scale. The flux-calibrated spectra in the two regions were combined to a weighted mean to give the final spectrum on a relative flux scale.
The sudden decline in the UBVRI light curves, coincidental with the increase in the luminosities in the NIR region (Arkharov et al. 2006), with a reddening of the colours, is quite similar to the behaviour of dust-forming novae (e.g. Gehrz 1988) and a clear indication of the formation of hot dust.

The optical ‘quasi-bolometric’ light curve is constructed using the UBVRI magnitudes presented here, and those published by Pastorello et al. (2007). Assuming a distance of 25.8 Mpc and a reddening of $E(B-V)=0.05$ (Pastorello et al. 2007), the observed UBVRI magnitudes were converted to monochromatic fluxes and integrated over the observed wavelength range to obtain the optical quasi-bolometric light curve. Likewise, combining the NIR magnitudes (Arkharov et al. 2006, Di Carlo et al. 2008, Mattila et al. 2008) with the UBVRI magnitudes, the optical-$\lambda$-NIR (uvoir) bolometric light curve was constructed integrating over the $U$ to $K$ bands (see also Pastorello et al. 2007; Di Carlo et al. 2008; Mattila et al. 2008; Tominaga et al. 2008). Fig. 5 shows the optical ‘quasi-bolometric’ light curve as well as the uvoir bolometric light curve. Also shown in the figure are the bolometric light curves of Type Ib/c SNe 1990I, 1994I and 1999ex and the Type IIn SN 1998S. It is evident from the plot that SN 2006jc has a luminosity that is higher than that of other Ib/c SNe, while it is about 1.6 mag fainter than the Type IIn SN 1998S. The optical luminosity of SN 2006jc indicates an early decline rate of 0.092 mag d$^{-1}$ until $\sim30$ d since maximum. A flatting is seen in the light curve during $\sim30$–50 d after maximum, with the decline rate during this period being 0.047 mag d$^{-1}$. The onset of dust formation is marked by a sharp decline in the optical luminosity, with a decline rate of 0.084 mag d$^{-1}$ during $\sim50$–100 d after maximum. In contrast to the optical luminosity, the uvoir bolometric luminosity shows a flat decline, with a decline rate of 0.026 mag d$^{-1}$ beyond day 35. A comparison with the bolometric light curves of other SNe indicates that the bolometric light curve decline of SN 2006jc is not too different from other normal SNe Ib/c. The early decline lies between the rapidly declining SN 1994I (0.106 mag d$^{-1}$) and the slower SN 1999ex (0.076 mag d$^{-1}$), while the uvoir decline rate at later phases is similar to SN 1994I (0.029 mag d$^{-1}$).

### 3.2 The spectrum and its evolution

The spectrum of SN 2006jc and its evolution during the phase 7 to 68 days since the estimated maximum on JD 245 4016 is presented in Figs 6 and 7. These spectra provide a fairly dense coverage of the early-time spectral evolution of SN 2006jc and are complementary in phase to those presented by Foley et al. (2007), Smith et al. (2008) and Pastorello et al. (2007, 2008). The spectrum is peculiar and different from that of normal Type Ib/c supernovae (Matheson et al. 2001; Branch et al. 2002). The photospheric P Cygni profiles that are typically found in the early spectra of Type Ib/c supernovae are absent, and the spectrum is characterized by (i) a steep, blue continuum shortwards of $\sim5500$ Å and (ii) dominant moderately narrow helium emission lines.
The line profiles of the strongest He I lines at 5876, 6678 and 7065 Å are shown in Fig. 9. From the figure, it appears that He I 5876 Å may have a contribution from the fast-moving supernova material. A broad component could be present in the 5876 Å profile.

Figure 2. \textit{UBVRI} light curves of SN 2006jc obtained with the HCT.

Table 3. Photometric observations of SN 2006jc.

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*With respect to date of maximum, assumed to be JD 245 4016.

Note. The errors quoted are the statistical errors associated with the magnitudes.

Broad emission features, due to the expanding supernova material, are also seen at ~3850, 4121, 5950, 6348, 7800, 8214 and 8500 Å. The features at λλ 3850, 5950, 7800 and 8214 are identified with Mg ii 3848, 3850 Å, 5938, 5943 Å, 7790, 7877 Å and 8214, 8234 Å respectively. The feature at 6348 Å is identified with Si ii λ 6355, probably blended with Mg ii 6346 Å, and the feature at 4121 Å could be due to Si ii 4128, 4131 Å. Si ii λλ 5041, 5056 could also be present. O i 7774 Å is also present, blended with Mg ii. The feature at 8500 Å is due to Ca ii infrared triplet. Mg ii 4481 Å could be blended with He i 4471 Å. The \textit{FWHM} of the broad features indicates a velocity of ~5000–6000 km s$^{-1}$. The strength of the Mg ii and Si ii features decreases with time, while that of the Ca ii IR triplet and O i 7774 Å increases with time. Fe ii features appear to develop in the 4500–5500 Å region, around 10 days after B maximum. The O i 7774 Å line shows a sharp P Cygni absorption during the early phases, with the absorption minimum indicating a velocity of ~620 km s$^{-1}$ (Fig. 8).

The He i line widths indicate a velocity of ~2200–3000 km s$^{-1}$. As noted by Foley et al. (2007), a narrow P Cygni component is noted in the He i 3889 Å line, at a velocity of ~620 km s$^{-1}$. A similar component could be present in the 4471 Å line also, at ~760 km s$^{-1}$. It is interesting to note that the velocity of the narrow P Cygni absorption seen in the O i 7774 Å line is very similar to the velocity of this component.

The line profiles of the strongest He i lines at 5876, 6678 and 7065 Å are shown in Fig. 9. From the figure, it appears that He i 5876 Å may have a contribution from the fast-moving supernova material. A broad component could be present in the 5876 Å profile.
in the spectra of days 3, 5, 6 and 9. A simple de-blending of the components, assuming a simple Gaussian profile for both components, indicates the broad component has a velocity of \( \sim 5000 \text{ km s}^{-1} \), similar to the supernova features. The broad component fades with time, in accordance with the evolution of the Mg \( \text{II} \) and Si \( \text{II} \) features from the supernova material. Pastorello et al. (2008) note the presence of helium in the fast-moving supernova ejecta in the early-phase spectra of SN 2000er which has been found to be very similar to SN 2006jc. This broad feature could also be due to Na \( \text{I} \) 5893 Å (Pastorello et al. 2007). The peak of the moderately narrow 5876 Å component shifts bluewards around day 10, and the line profile begins to show asymmetry that is clearly seen by day 20. A similar shift in the peak and asymmetry is seen in the 6678 Å line also, while the peak is blueshifted in the 7065 Å line all through. The 7065 Å line shows a clear double-peaked structure after day 12. The asymmetry in the line profiles at later phases was first noted by Smith et al. (2008) also, who find the asymmetry more pronounced in the spectra obtained at phases later than presented here, with the strongest decrease in the red side of the lines occurring between \( \sim 50 \) and 75 d, at the same time during which the red/IR continuum appeared and increased giving rise to a ‘U-shaped’ continuum.

H\( \alpha \) is clearly detected in all the spectra presented here, and is seen to increase in strength at the later phases. While it is seen in absorption during the early days, it evolves into an emission feature around day 18–20 (Figs 6 and 8). Pastorello et al. (2008) note that the supernova features faded completely beyond \( \sim 100 \) d, and the spectrum was completely dominated by narrow He\( \text{I} \) circumstellar lines. They also note that the strength of H\( \alpha \) is almost comparable to that of He\( \text{I} \) 6678 Å line at this phase.

3.3 The helium-emitting region

The progenitor of SN 2006jc was observed to undergo a luminous mass-loss episode, similar to the giant eruptions seen in LBVs, lasting about 10 d, two years prior to the supernova event (Nakano et al. 2006; Pastorello et al. 2007). If we assume that the helium emission lines seen in the supernova spectra arise in the shell ejected during the luminous event, and this shell is helium enriched, then the observed helium line luminosity may be used to estimate the density and mass of the shell. The observed, reddening-corrected He\( \text{I} \) 5876 Å and 7065 Å line fluxes are listed in Table 4.

If we assume the circumstellar shell (CS) ejected during the luminous mass-loss episode had a velocity of 600 km s\(^{-1}\), similar to the velocity of the narrow P Cygni absorption seen in the He\( \text{I} \) and O\( \text{I} \) lines, the radius of the shell would be \( 3.8 \times 10^{15} \) cm. The corresponding radius for a CS velocity of 2500 km s\(^{-1}\), as observed for the He\( \text{I} \) emission lines, is \( 1.6 \times 10^{16} \) cm. We also assume the thickness of the shell to be constant and determined by the observed duration (\( \sim 10 \) d) of the luminous mass-loss episode (Nakano et al. 2006). Using the observed reddening-corrected line fluxes and a distance of 25.8 Mpc, we estimate an average density in the range \( (0.54\text{--}3.7) \times 10^{10} \) cm\(^{-3}\) for a shell velocity of 600 km s\(^{-1}\). The corresponding mass range for this shell is \( M_{\text{He}} = 0.001\text{--}0.008 M_{\odot} \). Likewise, for a shell velocity of 2500 km s\(^{-1}\), the average density

\[ M_{\text{He}} = 0.001\text{--}0.008 M_{\odot} \]
Figure 4. Reddening-corrected $U - B$, $B - V$, $V - R$ and $R - I$ colour curves of SN 2006jc compared with other Type Ib, Ic and IIn supernovae.

Figure 5. The optical ‘quasi-bolometric’ and the uvoir bolometric light curves of SN 2006jc. Also shown in the figure are the $UBVRI$ bolometric light curves of the Type Ib/c SN 1999ex and SN 1994I and the uvoir bolometric light curve of the Type IIn SN 1998S.

lies in the range $(0.6–4.0) \times 10^{19} \text{ cm}^{-3}$ and the corresponding mass range is $M_{\text{He}} = 0.01–0.07 M_{\odot}$. The helium line emissivities are taken from Almog & Netzer (1989). The density estimates are consistent with that estimated by Smith et al. (2008). Based on the observed X-ray luminosities, Immler et al. (2008) estimate a lower limit to the mass of the X-ray emitting shell to be $0.01 M_{\odot}$, and the circumstellar density to be $\sim 10^{7} \text{ cm}^{-3}$. These estimates are much lower than the values implied by the helium emission lines. This indicates that the X-ray emitting region could be different from the region emitting the bulk of the helium lines.

4 DISCUSSION

SN 2006jc shows a very peculiar spectrum with a very steep blue continuum and dominated by moderately narrow He I emission lines. The presence of the moderately narrow emission lines is very similar to that observed in Type IIn supernovae, where the fast-moving supernova ejecta interacts with a pre-existing circumstellar material. The observed properties of SN 2006jc are very similar to the recent supernovae SN 1999cq, SN 2000er and SN 2002ao (e.g. Pastorello et al. 2008). A weak X-ray emission and UV excess have also been detected in SN 2006jc, providing further evidence for an interaction with a pre-supernova circumstellar material (Immler et al. 2008). A luminous mass-loss episode was observed in the progenitor of SN 2006jc two years prior to the outburst. It is suggested that the strong, intermediate width He I emission lines dominating the optical spectrum arise in the CS due to the recent mass-loss episode and that it is helium enriched (Foley et al. 2007; Pastorello et al. 2007; Smith et al. 2008). The fluxes of the He I emission lines indicate a density of $\sim 10^{19} \text{ cm}^{-3}$ and a helium mass $\lesssim 0.07 M_{\odot}$ in the CS that is assumed to have a velocity of 2500 km s$^{-1}$ corresponding to the $FWHM$ width of the He I lines. It is also quite likely that the velocity of the CSM shell was initially low, and accelerated to 2500 km s$^{-1}$ due to the interaction. In such a case, the initial
Figure 6. Spectroscopic evolution of SN 2006jc during +7 to +31 days since maximum on JD 245 4016. Note the fading of the broad features, the evolution of Fe II lines in the 4500–5500 Å region and the development of Hα line from an absorption feature into an emission feature.

Figure 7. Spectroscopic evolution of SN 2006jc during +39 to +68 days since maximum on JD 245 4016. Note the increase in strength of the O I 7774 Å and Ca II infrared triplet lines.
velocity of the shell is more likely to be in between the assumed velocities and the density of the shell $\sim 10^9$–$10^{10}$ cm$^{-3}$. The density estimated here is similar to that estimated by Smith et al. (2008). Comparing with Type IIn SNe, it is found that the estimated density range for SN 2006jc is somewhat higher than that estimated for IIn SNe, in which the CSM densities are found to range from $\sim 10^6$ (e.g. SN 1995N; Fransson et al. 2002) to $\gtrsim 10^8$ cm$^{-3}$ (e.g. SN 1995G, Pastorello et al. 2002; SN 1997eg, Salamanca, Terlevich & Tenorio-Tagle 2002).

Dust formation has been observed in SN 2006jc early on, at $\sim 50$ d past maximum (Di Carlo et al. 2008; Nozawa et al. 2008; Smith et al. 2008). Dust formation is reflected in the helium emission line profiles, which developed an asymmetric profile, with the red wing of the profile getting increasingly suppressed with time, and also in the increase in the red to NIR continuum between 65 and 120 d. Smith et al. (2008) estimate the dust temperature during this phase to be $\sim 1600$ K. The estimated densities in the shell are high enough to precipitate graphite dust (Clayton 1979).

Based on NIR and mid-IR (MIR) observations at $t \sim 200$ d, Sakon et al. (2008) conclude that IR emission originated from amorphous carbon grains with two temperatures of 800 and 320 K. Sakon et al., Nozawa et al. (2008) and Tomimaga et al. (2008) suggest the hot carbon dust is newly formed in the supernova ejecta and heated by the $^{56}$Ni-$^{56}$Co decay, while the origin of the warm carbon dust is a supernova light echo of the CSM carbon dust. For the dust to originate in the SN ejecta, it implies an ejecta radius of $\sim 10^{16}$ cm during dust formation. This in turn implies a (constant) velocity $\sim 25{,}000$–$30{,}000$ km s$^{-1}$. No evidence for such a high velocity is seen in the observed spectra. Based on a comparison of the early spectra of SN 2006jc with those of SN 2000er, Pastorello et al. (2008) suggest that SN 2006jc was discovered a couple of weeks after explosion or $\sim 10$ d after maximum light. Thus, very high initial velocities cannot be ruled out, as the initial interaction of the supernova material with the CSM material can lead to a deceleration of the supernova shell (e.g. Chevalier 1982).

On the basis of spectroscopic evidences, Smith et al. propose the site of dust formation to be a cold dense shell (CDS) behind the blast wave and that the shell was composed of dense CSM ejected by the luminous event, which was then swept up by the forward shock. They, however, do not rule out the possibility of dust formation in a carbon-rich SN ejecta. Mattila et al. (2008) also propose the CDS as the site for formation of the hot dust. However, they argue, based on the intensity, spectral energy distribution and evolution of the IR flux, that the IR emission in SN 2006jc is due to IR echoes. The bulk of the near-IR emission is due to an IR echo from the newly formed dust in the CDS, while a substantial fraction of the MIR flux is due to pre-existing dust in the progenitor wind due to an episodic mass-loss phase that ceased at least $\sim 200$ yr before the recent pre-supernova luminous outburst and the SN event.

The observed optical light curves of SN 2006jc show an early evolution that is quite similar to normal Ib/c supernovae. The initial decline is steep, and at about 20 days past maximum, the decline slows, a probable indication of the supernova having reached the exponential tail. Comparing the light curve evolution with Type IIn supernovae (e.g. SN 1998S), it is seen that the early decline is much slower in the case of SNe IIn, where the light curve is thought to be powered by the interaction of the supernova material with the CSM (e.g. Rigon et al. 2003). On the other hand, the light curve

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**Figure 8.** The OI 7774 Å line profile. Note the sharp absorption at $\sim 620$ km s$^{-1}$ (marked by the short vertical line) on days 7, 9 and 10, and its subsequent fading.
The optical spectrum and $UBVRI$ light curves of SN 2006jc during the early phases, until the onset of the dust formation, are presented here. The optical spectrum shows a blue continuum and is dominated by moderately narrow He I emission lines, similar to Type IIn SNe and an indication of the supernova ejecta interacting with a pre-supernova circumstellar material. The moderately narrow He I emission lines arise in the pre-supernova CS that is helium enriched.

The optical light curves show a clear signature of dust formation as indicated by a sharp decrease in the magnitudes around day 50, accompanied by a reddening of the colours. The evolution of the optical light curve during the early phases is very similar to normal Ib/c SNe. The $uv$ light bolometric light curve evolution of SN 2006jc is reasonably similar to normal Ib/c SNe at all phases.

The He I emission line fluxes indicate the CS is dense, with a density of $\sim 10^9 - 10^{10}$ cm$^{-3}$. The helium mass in this shell is estimated to be $\lesssim 0.07$ M$_\odot$.

5 SUMMARY

The optical spectrum and $UBVRI$ light curves of SN 2006jc during the early phases, until the onset of dust formation at $\sim 50$ d since maximum, is very similar to normal Ib/c objects. Comparing the bolometric light curve of SN 2006jc with normal Ib/c SNe and the Type IIn SNe, it is seen that the $uv$ bolometric light curve of SN 2006jc is very similar to the normal Ib/c objects, with a fast early decline followed by a flattening in the light curve $\sim 35$ d after maximum.

It is interesting to note that while the spectrum shows clear signatures of circumstellar interaction similar to Type IIn SNe, the bolometric light curve does not show any evidence of being powered by the interaction. We suggest that this is possibly a result of a weaker interaction in the case of SN 2006jc due to a shell mass that is lower compared to the mass of the circumstellar material in the case of IIn SNe (e.g. $\sim 0.4$ M$_\odot$ in 1994W, Chugai et al. 2004; $\sim 10$ M$_\odot$ in 1997eg, Salamanca et al. 2002).

Table 4. He I 5876 and 7065 Å emission line fluxes.

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1Average of 5876 and 7065.
2Assuming a shell velocity of 600 km s$^{-1}$.
3Assuming a shell velocity of 2500 km s$^{-1}$.
4Flux of de-blended narrow component.
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