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Supplementary Information

(1) Photometry of $NGC266\_LBV1$:

Here we report on the procedures used to validate the detection of $NGC266\_LBV1$ in the 1997 *HST* data and the calculation of the reported photometry. This constitutes a complete reanalysis of the data and supersedes the analysis given previously.[3]

The F547M dataset taken in 1997 consists of two undithered images, of durations 200s and 160s, taken in sequence. $NGC266\_LBV1$ is visible in both raw, unreduced images. We measured its photometry using `HSTphot`,[29] a custom software package designed to measure faint sources in *HST*/WFPC2 data, which we have tested and used previously.[3,30]

We first repeated our previous analysis procedure[3] using the latest version of the software (1.1.7b – includes all updates through 2005.06.07), and obtained results consistent with our earlier analysis, detecting $NGC266\_LBV1$ as a point source with $V = 24.1 \pm 0.1$ mag, at a signal to noise ratio (S/N) of 7.2. This was done by first combining the cosmic-ray-removed frames and then running `HSTphot` on the combined set. This is the optimal method to be used when the data set consists of numerous sub-images and cosmic-ray removal can be easily achieved, e.g., using median filtering of each pixel stack.

However, for the data set in question, with only two sub-images, this procedure may result in coincident cosmic-ray hits or hot-pixels being falsely measured as real objects. To further validate that the detection of $NGC266\_LBV1$ does not result from such effects we performed the following tests.

First, we ran `HSTphot` differently, by not combining the images, and letting the `HSTphot` machinery deal with 2 separate "epochs". In this mode, for a given object the software outputs both a final magnitude (i.e., what it derives from photometry of its internal combination of the frames) as well as individual magnitudes and shape parameters (e.g., PSF width, ellipticity, sharpness) for each of the separate "epochs". Superpositions of cosmic-ray hits (having different shape and flux) are then easily detected. Using this technique, $NGC266\_LBV1$ is again clearly detected as a bona fide object with $S/N = 6.2$ – slightly reduced since this analysis method, while more robust, is not optimized for maximum signal. We note that objects 2, 4, and 5 listed in Table 1 of reference [1] are not recovered by this improved analysis procedure, and are probably not real. Similar non-real single-pixel objects are visible in Fig. 1(a), e.g., due southeast and northwest of $NGC266\_LBV1$.

As a second test, we employed an independent cosmic-ray detection algorithm tuned to work on similar data, LACOS.[31] We ran this routine on each of the raw frames using the WFPC2-optimized recommended settings and produced cosmic-ray-cleaned versions of each raw image. Subtracting these from the original frames, we produced cosmic-ray maps of each raw frame. Inspecting the nominal location of $NGC266\_LBV1$ (Table 1) in these maps, we found no cosmic rays within 3 pixels of its location. Our LACOS analysis therefore verifies the validity of the detection of $NGC266\_LBV1$.

Detector artifacts (hot pixels) can also masquerade as genuine objects in data sets not composed of properly dithered sub-exposures. Fortunately, the full 1997 data set consists of 4 images – two in visible light (F547M) and two in the ultra-violet (UV; F218W). Since elevated count levels in defective hot pixels do not result from incoming radiation but from faulty electronics in the detector, they would appear in the same position on the detector and with approximately the same number of counts regardless of the filter used (visible or UV). These artifacts can thus be identified since they fall on identical locations in both the visible and UV exposures taken in 1997 and have similar flux levels (unlike most astronomical objects). We have identified such hot pixels in our data, and none are near the location of $NGC266\_LBV1$; our putative progenitor is well-detected in F547M images, while no object exists at the location in the UV frames. A hot pixel thus does not compromise the detection or photometry of $NGC266\_LBV1$.

For an additional, final test, we use the new observations obtained in 2007. These consist of four 400s-long exposures (i.e., each individual sub-image is longer than the combined 1997 data set) that were obtained with proper dithering, making the rejection of cosmic rays and hot pixels trivial. There are 15 sources detected in the 1997 data, on the three WF chips of the WFPC2 camera (the PC chip does not contain enough sources to allow comparison with the new data) with a similar S/N to that of $NGC266\_LBV1$ (which we defined as $5 < S/N < 7$), that were not flagged as cosmic rays or hot pixels using the methods described above. In particular, these are detected by `HSTphot` at $S/N > 3$ in both sub-frames, and have a "sharpness" value below 0.3, a "chi" value below 1.5, and a "roundness" value below 0.5 (see the HSTphot manual, available at: http://purcell.as.arizona.edu/hstphot). Of those, all but $NGC266\_LBV1$ are recovered in the 2007 data set, i.e., are confirmed to be real objects rather than image artifacts.

Table 1. Candidate LBVs in NGC 266

Star	WFPC2 chip	X,Y	V [mag] (1997)	V [mag] (2007)
$NGC266\_LBV1$	WF2	56.73, 157.86	24.1 ± 0.2	$< 25.6[< 25.9]^b$
$NGC266\_LBV2$	WF2	255.86 125.24	24.4 ± 0.2	25.02 ± 0.2
$NGC266\_LBV3$	WF4	332.79 478.30	24.2 ± 0.2	23.646 ± 0.004
$NGC266\_LBV4$	WF4	510.13 452.65	24.3 ± 0.2	24.8 ± 0.1

Notes:
[a] Object location on the coordinate system defined by *HST* dataset `u3mj0103m_c0f.fits`, obtained in 1997 and extracted from the space telescope science archive, with WF chips WF2 – WF4 being the second to fourth extension in the `.fits` structure format used, respectively. Pixel coordinates follow the `HSTphot` convention that an integer value is assigned to a star that is centered in the lower-left corner of a pixel. This is similar to `DoPHOT`, but is 0.5 pixel lower than in `DAOPHOT`. Note that $NGC266\_LBV1$ is the putative progenitor of SN 2005gl.
[b] Non detection upper limits are given at the $3\sigma[2\sigma]$ confidence level, respectively.

We note that three of these, all with luminosities comparable to that of $NGC266\_LBV1$, are variable at the ~ 0.5 magnitude level, as expected for LBVs.[4] In light of our results, these may well represent the progenitors of future supernovae in NGC 266, and we list their locations in Table 1.

As a final note, both authors have extensive experience with reduction and analysis of WFPC2 data. We have visually inspected the data and confirm that we see no peculiarities near the location of $NGC266\_LBV1$. We thus conclude that $NGC266\_LBV1$ is a real astrophysical object in NGC 266, clearly visible in the 1997 data. Its disappearance in 2007 confirms that it must have been a single star (since star clusters do not vary significantly in luminosity), as suggested, but not proven, by our original `HSTphot` analysis.

(2) Non-detection of $NGC266\_LBV1$ in 2007:

We have calculated upper limits on the non-detection of $NGC266\_LBV1$ in the new 2007 *HST* data by inserting artificial stars of known flux (corresponding to $23.2 < V < 26$ mag) into the location of $NGC266\_LBV1$ in the four raw frames from 2007 (pixel location [x,y]=[417.74, 438.68] on WF3). These artificial data sets were then combined and photometered using `HSTphot` in the same manner as the real data, with the exception that `HSTphot` was run in the "starlist" mode (i.e., option 1024), which forces it to measure the photometry of sources at stated locations, which included the nominal location of $NGC266\_LBV1$ (i.e., where the artificial source had been inserted). We find that artificial sources are detected down to $V = 25.6$ mag at $S/N = 3$, and down to $V = 25.9$ mag at $S/N = 2$. Analyzing the real data (i.e., without an artificial source added) in the same manner and forcing `HSTphot` to measure an "object" at the location of $NGC266\_LBV1$, results in a "detection" at $V = 27.9$ mag with $S/N = 0.2$, which can be taken as the most liberal upper limit on the flux from a putative remnant of $NGC266\_LBV1$. From this analysis we conclude that $NGC266\_LBV1$ is not detected in 2007 to a limit of $V = 25.6[V = 25.9]$ at the $3\sigma[2\sigma]$ confidence level†.

(3) Spectroscopic evolution:

Fig. 4 shows the spectral evolution of SN 2005gl, reproduced from reference [1]. The first epoch, obtained 8 days after discovery (8-33 days after explosion[3]) is essentially composed of a smooth blue continuum likely arising from the shock interaction zone with superposed narrow and intermediate-width emission lines. A dramatic evolution is observed 50 days later in our second spectrum which shows broad P-Cygni profiles and a general resemblance to spectra of ordinary SNe II-P (Fig. 5), which are known to result from the explosions of much lower-mass stars[8,32,9–11] whose ejecta suffer little circumstellar interaction. This likely indicates that the strong interaction phase of SN 2005gl has ended by this date. The last spectrum (87 days post-discovery) shows that the supernova has now entered the nebular (optically thin) phase, with much weaker continuum and broad, asymmetrical line profiles with a strong blue peak at -2,000 $\mathrm{km\,s^{-1}}$ and a modest red peak at +2,000 $\mathrm{km\,s^{-1}}$, with the full line extending out to $\sim \pm 7,000\,\mathrm{km\,s^{-1}}$. The asymmetries (most prominent in the Balmer Hα and Hβ lines) might reflect an asymmetry in the distribution of the CSM. Dust formation could also be playing a role in enhancing the blue side relative to the red, although it would indicate dust forming extremely early.

†The possibility that $NGC266\_LBV1$ is an unrelated LBV, spatially coincident with SN 2005gl, which had a flare in 1997 but declined below our detection threshold in 2007, seems to require too many coincidences to be viable.

This was seen in the case of SN 2006jc,[33] but was also accompanied by a near infrared excess which is not obvious in our spectra.

(4) The metallicity of $NGC266\_LBV1$:

In order to estimate the heavy element enrichment of the gas in the vicinity of $NGC266\_LBV1$ we have extracted the light that fell very close to SN 2005gl in the spectral image taken on 31 December 2005 (i.e., our day 87 spectrum of SN 2005gl). To do this, we defined an extraction aperture offset along the slit from the location of SN 2005gl from 2 – 3 times the seeing. Light in this region of the detector is dominated by emission from nearby gas clouds, as indicated by the spatial extent of the narrow nebular lines, which is significantly wider than the width of the point-like supernova. The extracted spectrum is shown in Fig. 6. No broad features, which dominate the supernova spectrum at this time (Fig. 4) are seen, indicating that supernova light does not substantially contaminate the extracted spectrum. Using this nebular spectrum we measured the strength of the narrow lines of oxygen (3,727 Å doublet) and nitrogen (6,584 Å), and derived[34] the oxygen abundance. Accounting for the noise and possible dust extinction (a Galactic extinction of $A_V = 0.23\,\mathrm{mag}$ and a possible host extinction $A_V < 0.1\,\mathrm{mag}$[3]) we find log [O/H] +12 = 9.1 ± 0.3, which, assuming the recent solar value, log [O/H] +12 = 8.66,[35] indicates a supersolar metallicity with an oxygen overabundance $2.8^{+2.7}_{-1.4}$ times solar for the gaseous environment of $NGC266\_LBV1$.

(5) Physical properties of the wind from $NGC266\_LBV1$:

We derive the velocity of the pre-explosion wind v_{wind} from the half-width at zero intensity (HWZI = $420\,\mathrm{km\,s^{-1}}$) of the narrow component of the Hα emission line (Fig. 2, inset), corrected for the instrumental line width. This wind velocity is typical for LBVs (e.g., eta Carina[36]), but not for red supergiants (typical wind speeds[18] of $20 - 40\,\mathrm{km\,s^{-1}}$) or Wolf-Rayet stars (typical wind speeds[37] of $1,000 - 5,000\,\mathrm{km\,s^{-1}}$). The shock velocity $v_{Shock} \approx 1,500\,\mathrm{km\,s^{-1}}$ is derived from the FWHM of the intermediate-width component detected in our day 8 spectrum (Fig. 2); the luminosity of this component $L_{int} = 2.8 \times 10^{39}\,\mathrm{erg\,s^{-1}\,cm^{-2}}$ is derived by integrating the continuum-subtracted spectrum with the narrow Hα and [NII] features (accounting for $\approx 1/3$ of the line flux) removed from the profile, and assuming a distance of 66 Mpc[3] to NGC 266. The absolute spectrophotometry produced by the instrument with which the relevant spectrum was obtained (SNIFS[3]) has been carefully calibrated for its primary science use (observations of SNe Ia) and its accuracy is typically better than 5%. The efficiency factor $\epsilon_{H\alpha}$ is generally assumed to be below 0.1, with $\epsilon_{H\alpha} = 0.1$ seen as an appropriate selection for a young supernova[15] (and providing a lower limit on $\dot{M}$). The resulting mass-loss rate calculated from the formula $L_{int} = \epsilon_{H\alpha}\dot{M}v^3_{shock}/4v_{wind}$[15] is $\dot{M} = 0.024$ solar masses per year assuming no extinction, which is adjusted to $\dot{M} = 0.029$ solar masses per year by correcting for the Galactic extinction in the direction of SN 2005gl, and up to $\dot{M} = 0.031$ if we allow also for the likely upper limit on dust extinction in the host $A_V < 0.1$ mag.[3] We adopt $\dot{M} \approx 0.03$ solar masses per year as the likely value for the mass loss from $NGC266\_LBV1$ prior to explosion. This value is too high for essentially any class of massive stars other than LBVs in the eruptive phase.[4]

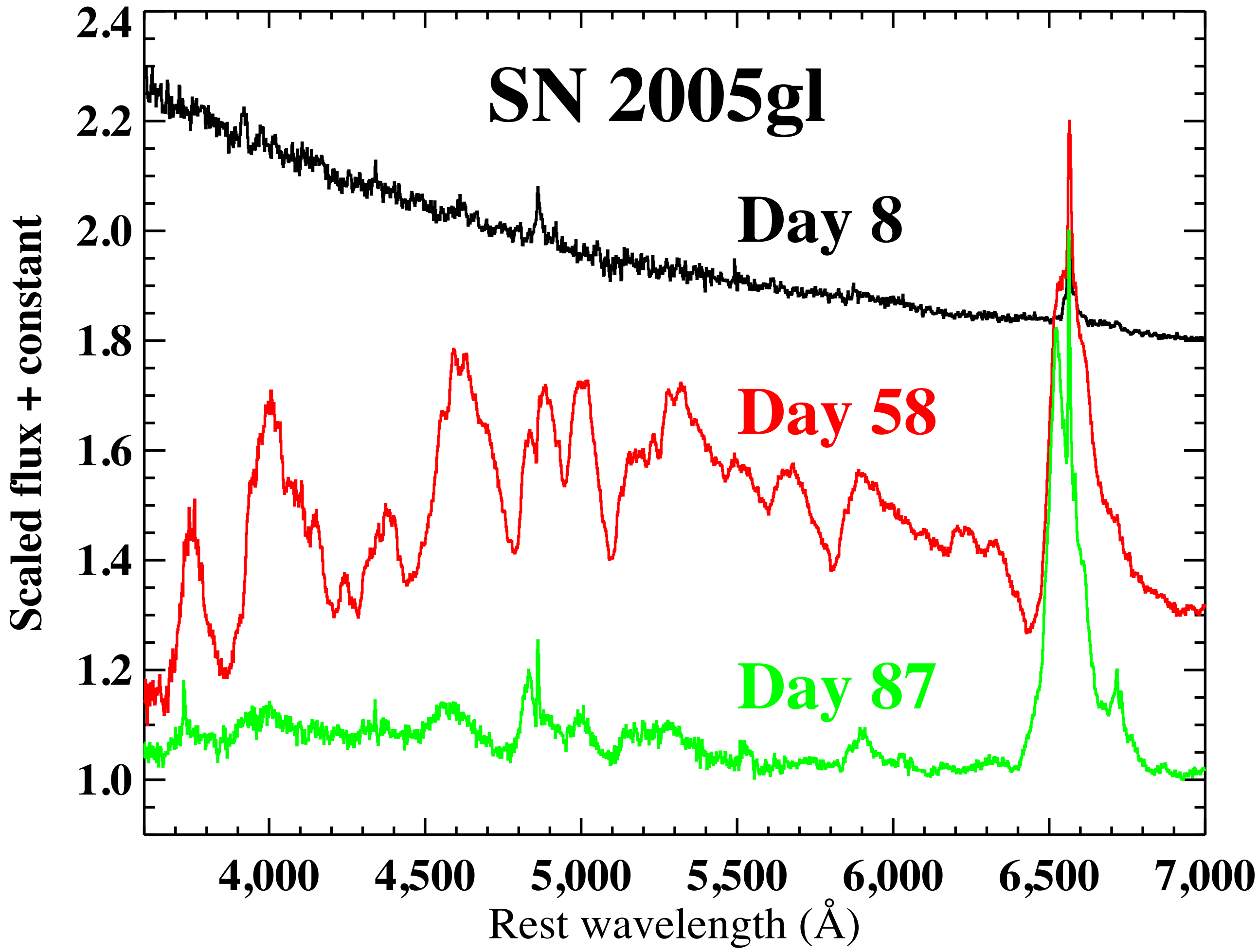

Figure 4.

Full visible-light spectra of SN 2005gl. Note the rapid transformation from an almost featureless shock-dominated early-time spectrum (day 8), to a mature, normal-looking non-interacting supernova (day 58), to a nearly nebular spectrum by day 87. In particular, the contribution of the shocked material that dominates the early spectrum is greatly reduced in the later spectra. Specifically, little evidence for "muting" of the P-cygni profiles[38] is evident in the photospheric-phase spectrum taken on day 58 (Fig. 5), a trait commonly seen in SNe IIn when the ejecta are actively interacting with circumstellar material.[39]

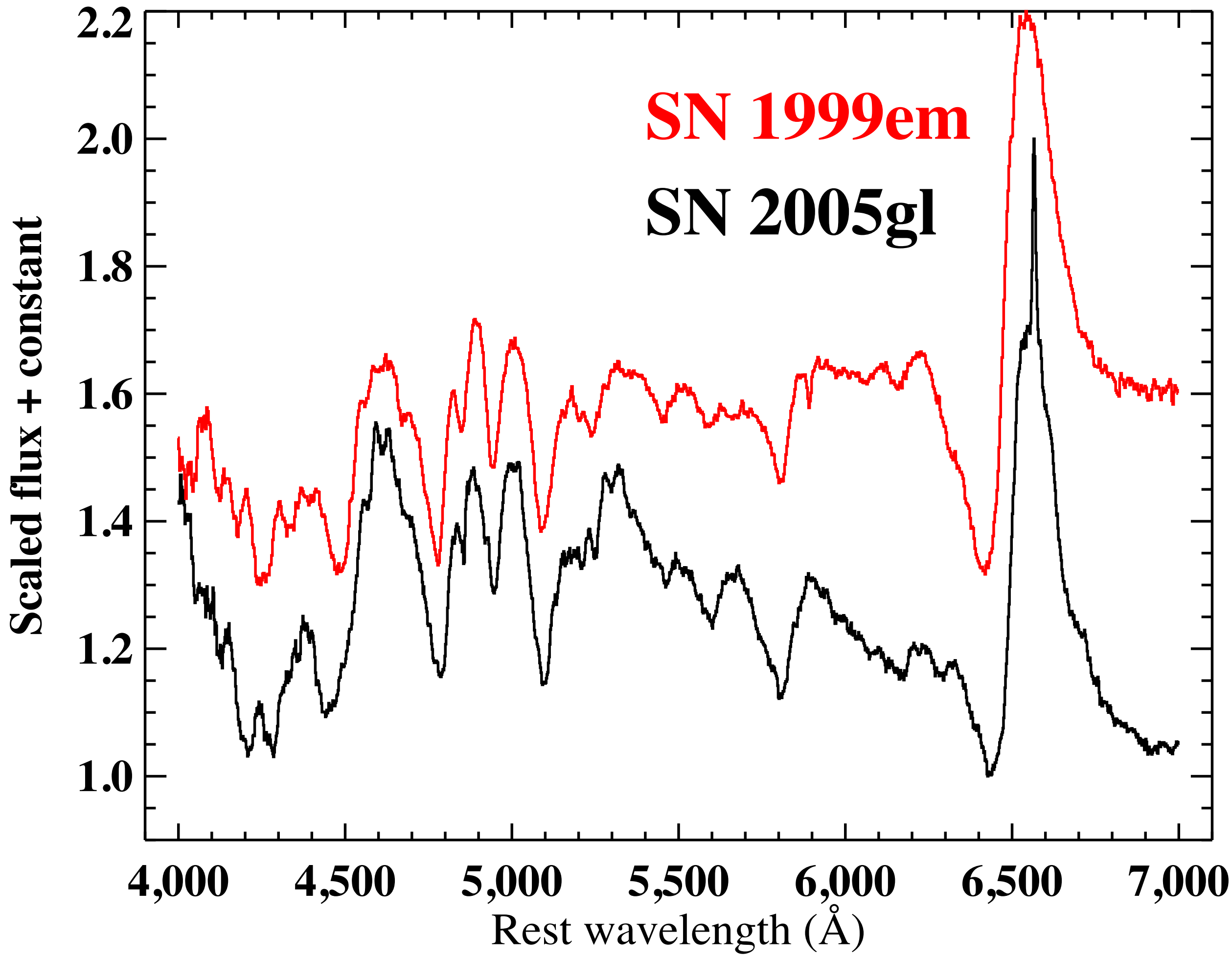

Figure 5.

Similarity between the spectrum of SN 2005gl 58 days post-discovery and a spectrum of the typical type II-P event SN 1999em (26 days post discovery[40]). SNe II-P are known to result from relatively low-mass progenitors (8-20 solar masses, initially) that explode as red supergiants,[8,32,9,10,41,42] and show little evidence for interaction with material lost by the progenitor prior to explosion. In our spectrum, except for a somewhat shallow P-cygni absorption in Hα and the narrow Hα emission line which probably includes a contribution from recombination of photoionized progenitor wind that has not yet been reached by the supernova ejecta, there are few obvious signs of interaction at this phase.

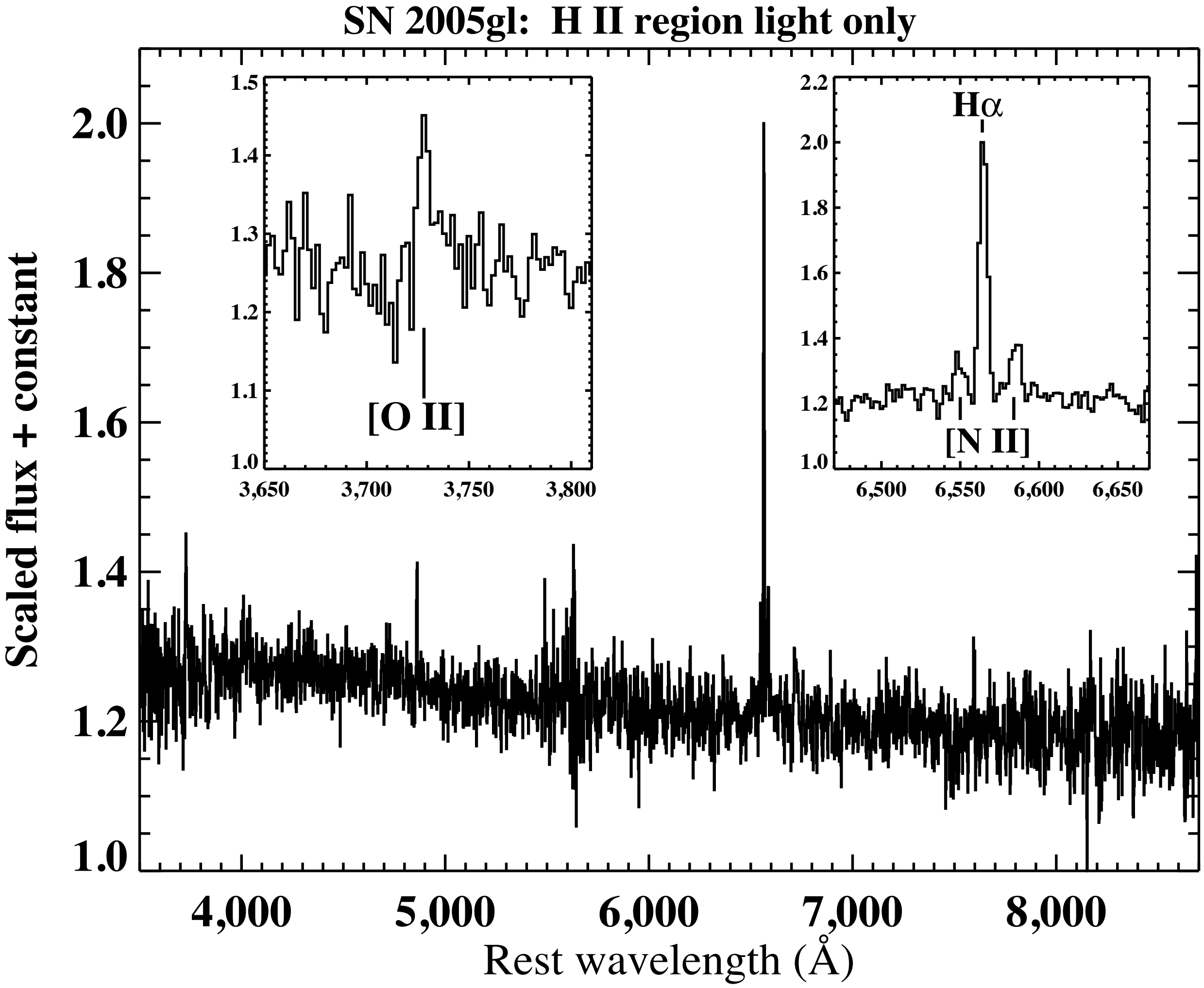

Figure 6.

Analysis of the light from gas clouds near the location of $NGC266\_LBV1$. We have extracted the light slightly off-source from the 2-d spectral image of SN 2005gl obtained on 31 December 2005. Note that no broad supernova features are seen, indicating that the measurements of narrow nebular lines of oxygen and nitrogen are not significantly contaminated by supernova light. Using the relation between the the ratio of ionized nitrogen ([NII] λ6,584 Å) to oxygen ([OII] $\lambda\lambda$3,726,3,729 Å),[34] we measure a supersolar metal abundance of [O/H] +12 = 9.1 ± 0.3, indicating that SN 2005gl exploded in a metal-rich area.

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