# What's New Around Supernova 1987 A?

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## New Hints of Resolved Gaseous Emission from Circumstellar Material Surrounding the Supernova Location

The apparition of SN 1987 A on February 23, 1987, in the Large Magellanic Cloud, the brightest SN in the last 3 centuries, provides a unique opportunity to test the theory of supernovae and also to follow for the first time the birth of the gaseous supernova remnant and to check the theory of the interaction of the radiation and the blast wave of the SN with the surrounding gas.

Two years after the event, evidence starts to become available on extended gaseous emission from ionized gas in the vicinity of the SN, based both on spectra and on direct imaging. Heathcote, Suntzeff and Walker (IAU Circular 4753) reported the detection of diffuse emission around the SN extending up to 2 arcsec in CCD observations on March 7, 1989 through broad band filters in good seeing.

On April 1, one of us (S.D.) observed the SN with EFOSC at the 3.6 m telescope in the light of B, V, R and through an interference filter centred on the [O III] emission line. One hour for these observations was kindly made available by J. Melnick.

The FWHM of stellar images in the original image (Fig. 1 a) is 0.85 arcsec with a sampling of 0.34 arcsec/pix. The supernova is well separated from its two "companion" stars and extended emission is clearly detected between PA 320° and 360° at a distance of about 2 arcsec from the SN: the feature is not seen in the broad band filters which have slightly worse image quality.

In order to determine the position of the two stars and the supernova, we have deconvolved the image with an empirical point spread function (PSF) constructed from the images of 17 other stars in the rest of the frame. Figs. 1 b and c show the effect of the deconvolution after 5 and 20 iterations, respectively. The astrometry was then done by fitting simple gaussians to the deblended stellar images. One should be aware that the ring-like structure which evolves around the supernova with increasing deconvolution (Fig. 1 c) is an artefact which, however, occurs only if a point source is superimposed on an extended object. This is an additional hint that there is an extended component around the supernova.

In the next step, we have scaled the PSF by trial and error to best match the flux in the raw image. From the positional information and the flux scaling factors a synthetic image was constructed and subtracted from the raw data. The residuals are shown in Figure 1 d. There are some artefacts which are due to the spatial truncation of the PSF and an imperfect compensation of the diffraction pattern of the secondary mirror support structure. Both effects occur because the PSF had to be constructed from much fainter stars than the supernova. There is no doubt that a highly significant extended emission in the [O III] band is present around the supernova (note that the stellar component of the SN almost certainly was considerably overcompensated). The stronger components seem to be aligned in the East-West direction but the farthest extension of the emission is seen to the North of the SN.

The results reported here are only preliminary, and we feel that additional observations under good seeing conditions are required for confirmation of the structural details. The presence of [O III] emission up to 2 arcsec from the SN is however proved beyond any doubts. A quick inspection of the R image suggests that diffuse emission is present at these wavelengths as well and it is particularly strong between position angles 270° and 300° within 2 arcsec from the SN.

We know from spectroscopic observations that the ionized gas is indeed there. A detailed study of the tiny, barely

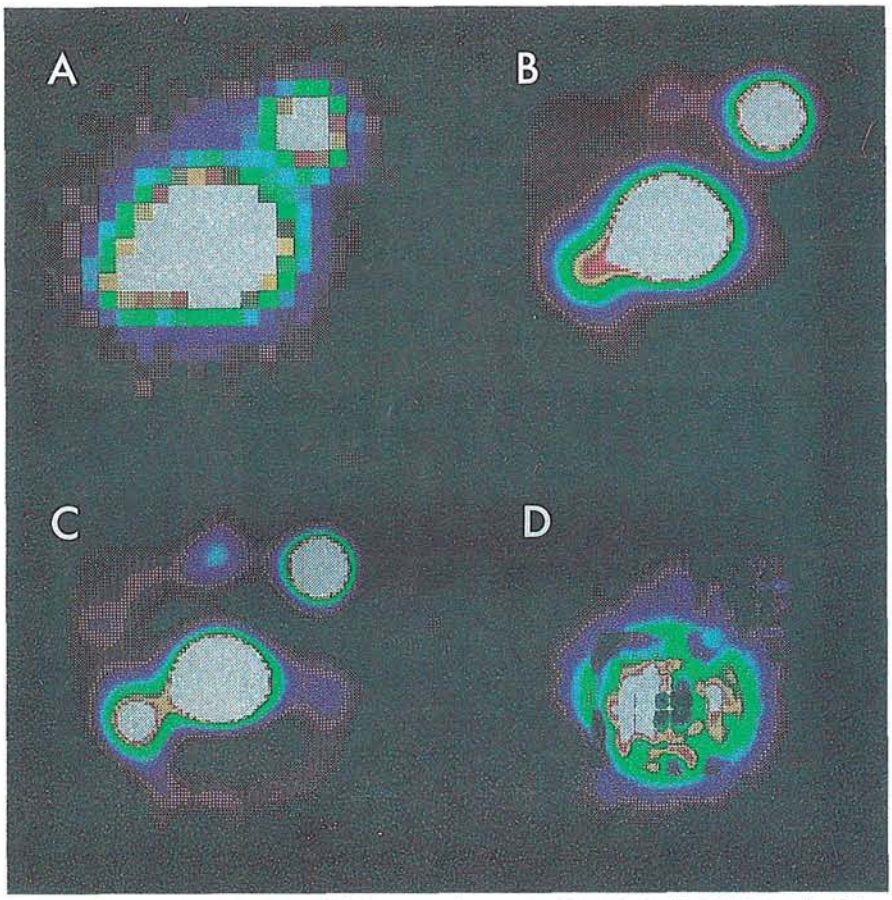


Figure 1: *Panel a: SN 1987A in a CCD image taken on April 1, 1989 with EFOSC at the 3.6 m telescope through a narrow filter centred at 5007 Å. The SN has a V magnitude of about 12.5, the companion star No. 2 is at 2.9 arcsec and PA = 320° and 2.5 magnitude fainter, the companion No. 3 is at 1.5 arcsec at PA = 120° and 3.2 mag fainter. Panel b: The same image after rebinning to a step of 0.2 the original pixel size and simultaneous deconvolution (5 iterations) with the point spread function. Panel c: Dito, except for 20 iterations. See text for a discussion of the ring structure. Panel d: The residual of the observations from the image reconstructed as described in the text. (This image was rebinned in a straightforward linear way to a step of 0.1 the original pixel size.) Apart from some artefacts explained in the text, there is significant extended emission around the supernova. – Note that all four figures have identical spatial scales and colour codings.*

resolved emission nebula around the SN has been carried out with the ESO echelle spectrograph by Wampler and Richichi (1988, *The Messenger* No. 52) and Wampler (1989, preprint). The emitting gas is likely to be the remnant of the stellar winds of the supernova precursor star and it appears unevenly distributed.

In March 89, three high resolution spectra (R = 60,000) were also obtained by S.D. with the CES spectrograph, linked via a fibre to the 3.6 m telescope, which provide additional information on the circumstellar gas. The aperture on the sky corresponds to 3.4 arcsec. A first spectrum was taken in the region of the interstellar NaI absorption lines. A cursory inspection shows no strong variations in the absorption components with respect to the spectra taken immediately after the explosion. Two more spectra were obtained at the strong [NII] and [OIII] emission lines (658.4 and 500.7 nm respectively) seen at a velocity of about 287 km/sec. The [NII] line shows a single, narrow component. The [OIII] line shows close to the main component of FWHM = 17 km/sec a much fainter one, of about the same width, blueshifted by 29 km/sec. On the red side of the main component a faint, broader component extends to about 90 km/sec. The velocity structure points to the presence of different components of highly ionized gas moving at different velocities.

While the full interpretation of these features require more data, it is clear that a new, fascinating phase in the formation of the remnant of SN 1987A has started. Close monitoring of its evolution in the next year bears great promise of new interesting discoveries.

# The Remnant of SN 1957d in M83

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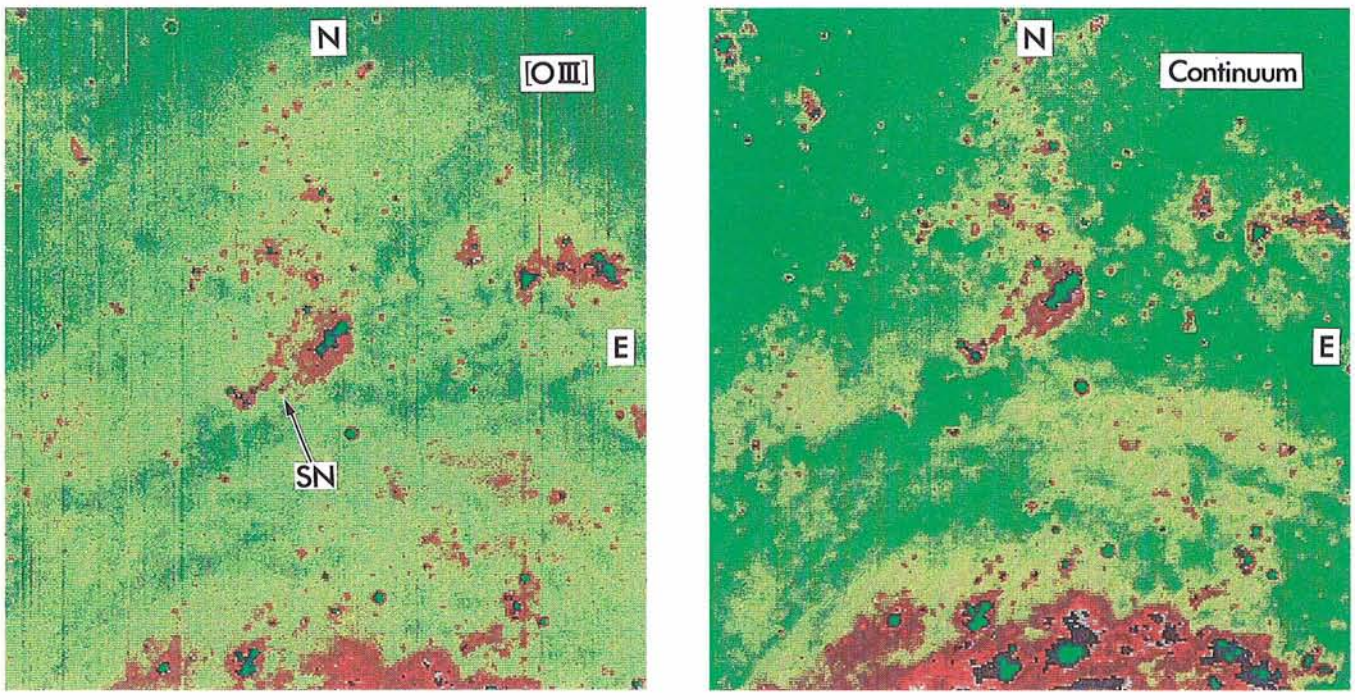
A pilot programme dedicated to studying previously reported extragalactic supernovae of advanced age (> 300 days) has had some early success with observations made at La Silla in April 1989. We report here the detection from direct imaging, and subsequent spectroscopy of the remnant of SN 1957d in M83. This galaxy has been a prolific producer of SNe this century (5 so far), and therefore offers a good opportunity for studying evolutionary effects in SNe of different types concentrated in a small area of sky. Unfortunately SN 1957d was not a well observed SN at early phases, and therefore neither the light curve nor the early spectroscopy was available to ensure an unambiguous classification. We now know that many SNe, as they age, develop strong lines of [OI] λλ 6300,63 or strong lines of [OIII] λλ 4959, 5007, and these characteristics facilitate detection by using narrow band filters to image objects in the light of these emission lines. Figure 1 shows the result of imaging of an area of M83 in the light of (a) [OIII] λ 5007 and (b) a nearby continuum wavelength with EFOSC on the 3.6 m telescope. The arrow points to the position of an object with enhanced brightness in the [OIII] λ 5007. This object coincides closely with the known reported position of SN 1957d.

Figure 2 shows a spectrum of this object, of approximately 20 Å resolution, resulting from a total exposure time of 200 minutes with the B300 grism in EFOSC. The most striking feature of this spectrum is the broad line blend of [OIII] λλ 4959, 5007. A weaker broad line feature due to [OI] λλ 6300,63 is also evi-




(a) (b)

Figure 1: *(a) Direct CCD image of M83 with narrow band filter isolating [OIII] λ 5007 emission. (b) Direct CCD image of M83 with narrow band filter isolating continuum emission.*