The Supernova in the LMC

During the night of 23/24 February, I. Shelton at the University of Toronto station at Las Campanas discovered a supernova in the Large Magellanic Cloud – the first naked-eye supernova to be seen since Kepler observed his "nova" in 1604. From the following night on, most ESO telescopes have been used to observe this object. The extraordinary brightness of this supernova for the first time allows very detailed observations to be made of the still mysterious supernova process, which involves the collapse and subsequent explosion of a star at the end of its evolution, and the probable genesis of a neutron star. In addition, this brightness allows studies to be made of the halo of our Galaxy and of the intergalactic medium by observations of absorption lines produced by the intervening matter. The absorption line data obtained with the High Resolution Spectrograph at the 1.4-m CAT have been unexpected and qualitatively superior to anything obtained before in the LMC.

In the last decades, supernovae have been observed in other galaxies; these supernovae, however, were always more than a hundred times fainter than the one in the LMC. While studies made with large telescopes at La Silla and elsewhere have yielded interesting data, no very high resolution studies were possible. With the full light gathering power of the VLT, however, fainter supernovae in other galaxies as well as some stars in the LMC will be observed with the same spectroscopic resolution as has been possible now for the LMC event. This supernova thereby gives us a preview of the discoveries that can be made with the VLT.

Following the discovery of the supernova, the telescope schedules have been changed and many planned programmes have not been executed. All observers at La Silla have switched over to the supernova with much enthusiasm. While for their coinvestigators it may be disappointing not to receive the data from their planned programmes, we expect that they will understand that it was not possible to continue business as usual in the light of this event. The initial data will be published very rapidly to ensure that the scientific community be fully informed.

L. WOLTJER, Director General of ESO

The Initial Impact of the LMC Supernova

Between 2 o'clock and 7 o'clock universal time (UT) on Monday morning, February 23, 1987, a star in the Large Magellanic Cloud (LMC), at the position of the B3 I supergiant Sanduleak −69202, began to brighten rapidly. By 10 o'clock UT it had brightened by a factor of 200. And the next day it had increased in brightness by an additional factor of 10. As L. Woltjer notes above, this star is the first really bright supernova in the modern era. Because of its southern declination it can only be seen by southern observatories and space observatories.

The excitement generated by the supernova is intense. It is unusual in a number of respects and it is bright enough to be studied in great detail. It is nearly certain that the progenitor of the supernova is Sanduleak −69202. Since B supergiants were not believed to be evolved enough to undergo the core collapse necessary to produce a supernova, it had been thought that only M giants or supergiants could be the progenitors of supernovae. The LMC supernova is the first type II supernova to be seen in an irregular galaxy. It has long been a mystery why type II supernovae were not seen in irregular galaxies. Also this supernova is 2 to 5 magnitudes (up to a factor of 100) fainter at maximum light than expected. This might be due to the fact that the progenitor is a B star rather than an M star. It has been suggested by Truran, Höflich, Weiss and Meyer (private communication) that the difference between this supernova and Type II supernovae in other galaxies is attributable to the low metallicity of the Large Magellanic Cloud. Brunish and Truran (1982, *Astrophysical Journal, Suppl.* **49,** 447–468) have shown that metal poor B stars may never become M supergiants prior to the onset of carbon burning. According to Peter Höflich at the Max Planck Institute for Astrophysics, the B star envelope has a steeper density gradient than the M star envelope. The denser inner envelope may trap the photons and result in a fainter maximum than would be the case if an M star had exploded. Because of this, more energy can be converted into kinetic energy in the outgoing matter. Since the LMC is metal poor, this model may explain the explosion of Sanduleak −69202. These authors also note further that it helps us to understand why we have not previously observed Type II supernovae in irregular galaxies. In any case, the future development of the supernova and more detailed modelling can probably resolve these questions.

There is one characteristic of the LMC supernova that is not modest. The Hα line shows structure 1000 Å wide. This corresponds to velocity outflow of 25,000 km/sec. If the envelope continues to expand at this rate it will subtend an angle of nearly 1/4 arcsec at the end of a year. When the VLT is completed about 10 years from now, the envelope will be big enough for detailed study by the VLT.

Early excitement was generated by CES spectroscopy of interstellar (and intergalactic!) atomic lines. The Ca II, H and K lines were broken into over 20 components with velocities ranging from the Galactic value to the velocity corresponding to the LMC, and numerous lines with intermediate velocities showed the presence of intergalactic clouds. When CES spectra are combined with far ultraviolet spectra taken with IUE it will be possible to determine the details of the ionization structure and abundances of the interstellar clouds in the line of sight to the supernova. The LMC supernova is already a bright radio source and it is very likely that it will become sufficiently bright for radio observations to determine the neutral hydrogen column densities in these clouds. Such studies illustrate the value of exploiting a temporarily bright source in order to study the physics of the intervening material.

These reflections are being written one week after the explosion. We still have much to learn. Does the LMC supernova represent a new, previously unknown class of supernova? Will we see changes in the interstellar lines that will indicate the size of these gas filaments? Can model calculations together with early observations accurately pinpoint the moment the envelope began to expand? If so, what is the time delay between the beginning of the expansion and neutrino burst detected by the Mont Blanc Neutrino Observatory? When will we be able to see the inner part of the expanding envelope with its rich soup of the products of nuclear fusion? Surely this supernova will be one of the most actively studied objects in the sky for years to come.

J. Wampler (ESO)

A workshop will be held at the ESO Headquarters in Garching from July 6–8, 1987 on

"The Supernova in the LMC"

Data obtained during the first half year of the supernova will be presented and other evidence and theories about supernovae confronted with the data.

For further information please contact:

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Walraven Photometry

The measurements were converted from log intensity to magnitudes.

UT	V	V−B	B	B−L	L	B−U	U	U−W	W
WAVEL. (Å)	5467		4325		3838		3633		3255
BANDW. (Å)	710		420		220		230		160
Feb.									
25.02	4.64	−0.19	4.83	−0.12	4.95	−0.13	4.96	−0.14	5.10
25.15	4.57	−0.19	4.76	−0.11	4.87	−0.11	4.87	−0.10	4.97
26.01	4.55	−0.26	4.81	−0.24	5.05	−0.31	5.12	−0.18	5.30
26.20	4.53	−0.26	4.79	−0.28	5.07	−0.33	5.12	−0.14	5.26
27.01	4.48	−0.39	4.87	−0.48	5.35	−0.65	5.52	−0.57	6.09
27.17	4.45	−0.40	4.95	−0.50	5.45	−0.71	5.66	−0.65	6.31
28.01	4.46	−0.56	5.02	−0.72	5.74	−1.26	6.28	−1.09	7.37
28.10	4.45	−0.54	4.99	−0.72	5.71	−1.27	6.26	−1.02	7.28
28.24	4.45	−0.56	5.01	−0.76	5.77	−1.35	6.36	−1.02	7.38
+/−	0.02	0.02	0.04	0.02	0.04	0.02	0.06	0.02	0.09

Observed by F. Steeman on the Dutch 91-cm telescope on La Silla.

P. Monderen, H.E. Schwarz (ESO), and F. Steeman (Leiden).

Geneva Seven Colour Photometry

The Supernova 1987A in LMC was measured 46 times between February 25 and March 2 in the seven filter Geneva photometry (Golay, M., 1980, *Vistas in Astronomy*, vol. 24, 141) at the ESO La Silla observatory.

SN 1987A was measured together with the comparison star HD 37935, a Geneva standard star. It should be

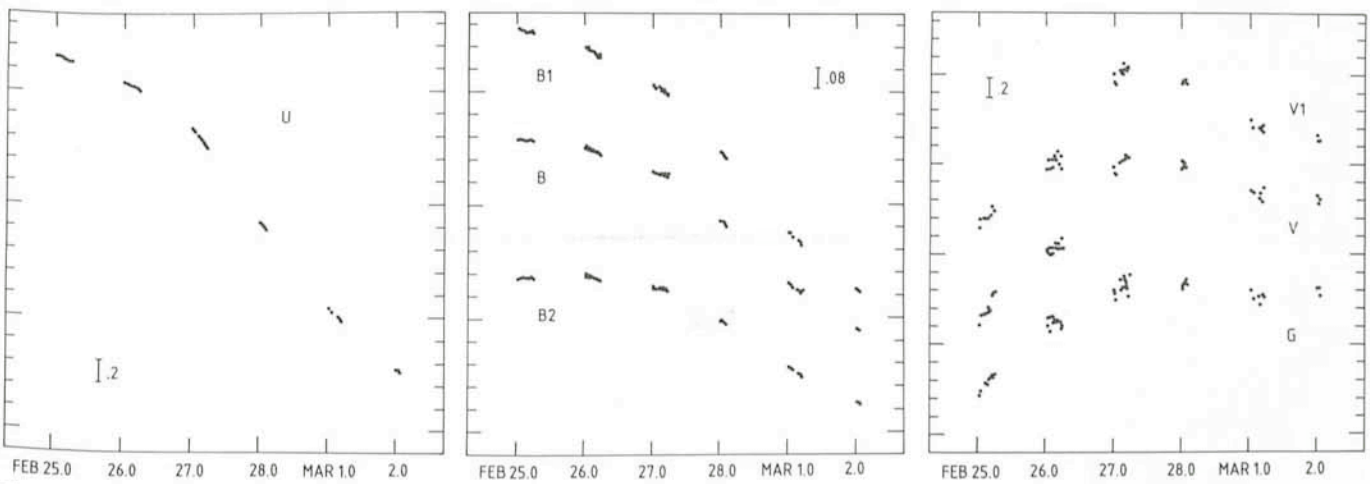

Figure 1: *(a) U magnitude relative to the comparison star HD 37935; (b) B 1, B and B 2 magnitudes relative to the comparison star HD 37935; (c) V 1, V and G magnitude relative to the comparison star HD 37935.*