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569. R. Arsenault et al.: A Circumnuclear Ring of Enhanced Star Formation in the Spiral Galaxy NGC 4321. *Astronomy and Astrophysics.* February 1988.
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571. J. Surdej et al.: Search for Gravitational Lensing from a Survey of Highly Luminous Quasars. *P.A.S.P.* February 1988.
572. R. Buonanno et al.: CCD Photometry in the Metal Poor Globular Cluster NGC 7099 (M30). *Astronomy and Astrophysics.* February 1988.

From the Editors

In accordance with the new management of ESO, it has been decided that the ESO *Messenger* shall above all be a vehicle of communication between ESO and the user community. It is therefore the intention to bring the fullest possible information about new developments at ESO, technical and scientific, as well as those of a more administrative nature. In a similar spirit, we herewith invite contributions from users, in the form of articles and also as shorter Letters to the Editor.

Tentative Time-table of Council Sessions and Committee Meetings for First Half of 1988

May 2	Users Committee
May 3	Scientific Technical Committee
May 4–5	Finance Committee Oberkochen
May 31–June 1	Observing Programme Committee, Liège
June 6	Committee of Council
June 7	Council

All meetings will take place at ESO in Garching unless stated otherwise.

SN 1987A: Spectroscopy of a Once-in-a-Lifetime Event

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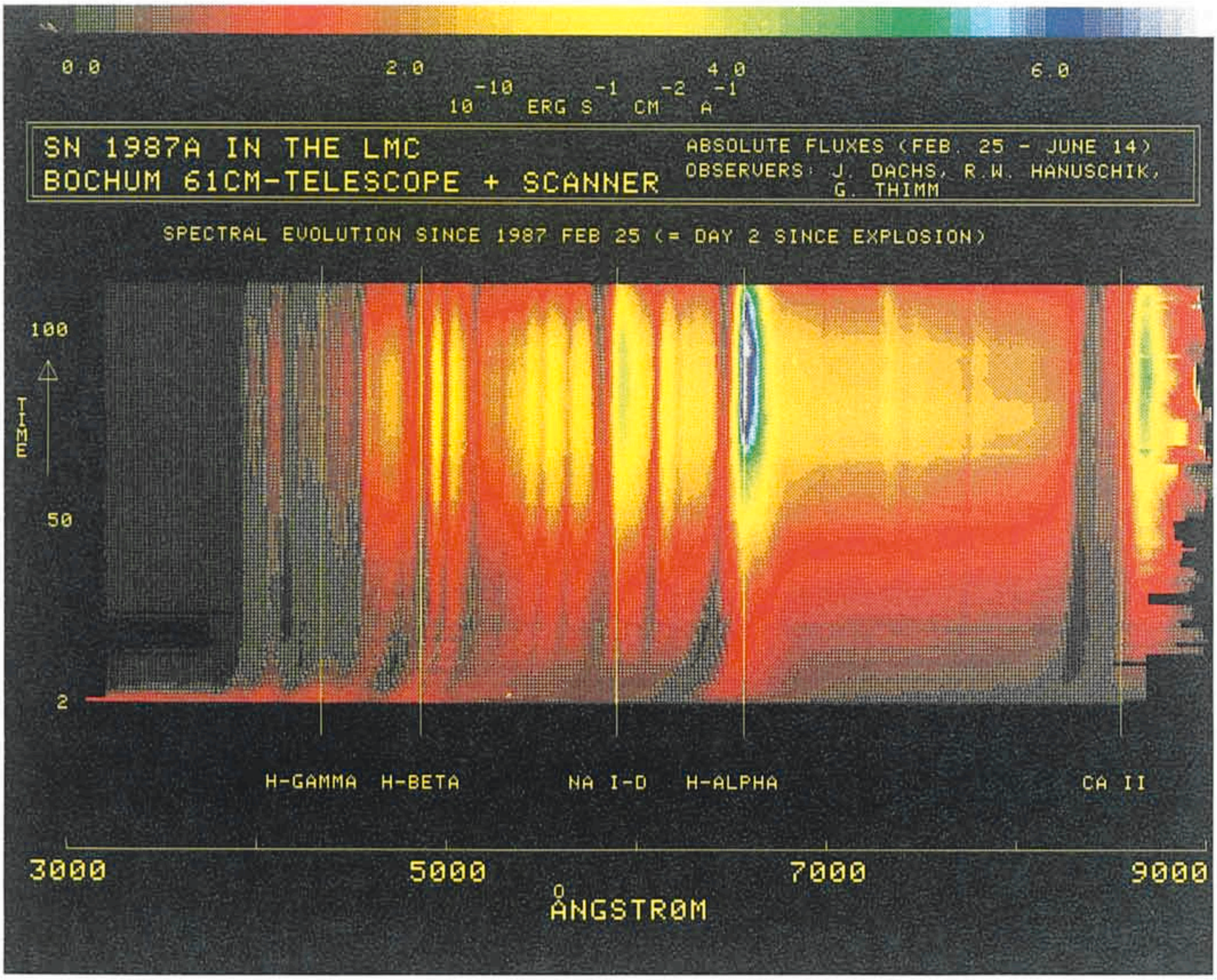
When Supernova 1987A in the Large Magellanic Cloud was discovered by Ian Shelton at Las Campanas Observatory in Chile on February 24, 1987, it immediately became apparent that this would turn out to be one of the most important astronomical events in this century. The timing of the supernova could not have been better – although the light from the site of the stellar collapse had to travel a distance of as much as 170,000 light-years before reaching our planet Earth, it arrived precisely when state-of-the-art photoelectrical detectors had become available at modern telescopes situated at the best observing sites all over the world, together with highly sophisticated spaceborn instruments working in the X-ray and ultraviolet regions of the electromagnetic spectrum. Even elementary particle physicists were well-prepared (except for some problems with their clocks) to catch two dozens of the neutrinos emitted by the dying star thereby providing for the first time the precise date of the collapse. (Only gravitational wave astronomy has still to wait to be born: all potential detectors had been switched off or did not work properly.)

To render the combination of privileges for earthbound observers even more impressive, SN 1987 A is just at the optimum distance for convenient measurements in the optical window: a galactic supernova would be too bright for professional astronomical instruments such as photometers and spectrometers which are especially designed to achieve the highest possible sensitivity for extremely faint radiation sources, and which therefore are in great danger to be destroyed when exposed to a naked-eye object. This problem has been discussed in greater detail in two papers by Michael Rosa and O.-G. Richter (*Observatory* **104,** p. 90 [1984]) and by Theodor Schmidt-Kaler (same volume, p. 234). Furthermore, a nearby supernova could not tell us very precisely its distance due to the strongly varying amount of dust in the galactic plane.

If SN 1987A were a distant supernova such as they are detected almost once per month, nobody would have obtained enough observing time at large telescopes in order to study and monitor it in sufficient detail for a long time. And again, the distance to a supernova beyond our Local Group of galaxies would be quite uncertain as compared to the well-defined and well-known distance to the LMC.

So it is not surprising that starting on February 25 literally every telescope in the southern hemisphere was directed towards the newly-born supernova (unfortunately enough, no spectrum exists from the night before when Ian Shelton made his discovery). This was of course also the case at the European Southern Observatory in Chile at La Silla where



This colour-coded plot of optical spectra depicts the dramatical spectral evolution of SN 1987A within the first 110 days (Feb. 25 to June 14). All spectra have been measured with the spectrum scanner attached to the 61-cm telescope of the University Bochum located at the European Southern Observatory at La Silla, by observers Joachim Dachs, Reinhard W. Hanuschik and Guido Thimm. The wavelength range covered is approximately 3200 to 9000 Å, the resolution is 10 Å. Absolute fluxes have been colour-coded according to the colour bar on top of the figure: colours run from black (zero flux) to blue-white (6.7 10^{-10} erg s^{-1} cm^{-2} $Å^{-1}$). Time series starts on February 25 (= day 2 since explosion); time scale is continued from bottom to top day by day. Last date is June 14 (= day 110).

one of us (J.D.) happened to work with the 61-cm telescope of the Ruhr-Universität of Bochum.

He was working on a long-term programme to monitor spectral and photometric variability in Be stars and original plans were to change instrumentation just in the afternoon of February 24, from the spectrum scanner equipped with a red-sensitive gallium-arsenid photomultiplier to the single-channel photometer. This plan, however, was rapidly given up, when the Acting Director, Hans-Emil Schuster, walked into the Hotel Dining Room during tea-time – the La Silla astronomers' breakfast – and announced the discovery of a supernova in the Large Magellanic Cloud. (In fact, the first IAU telegram did not mention that SN 1987A had been discovered at Las Campanas Observatory, only some 30 km from La Silla, and Hans-Emil Schuster first appeared to be rather sceptical about this event.) A few hours later, the first spectra of the supernova were obtained at La Silla, about 170,000 years plus 42 hours after the stellar collapse in the LMC.

Due to an agreement between ESO and the University of Bochum, the Bochum Astronomical Institute has access to this telescope during a total of eight months per year. In addition, ESO Director General Prof. Woltjer generously agreed to dispense with the four-month ESO period at the Bochum telescope as long the supernova could be observed.

So Joachim Dachs, and following him, Reinhard Hanuschik, Guido Thimm, Klaus Seidensticker, Josef Gochermann, Stefan Kimeswenger, Ralf Poetzel, Gerhard Schnur and Uwe Lemmer established a homogeneous series of flux-calibrated spectra obtained with a fixed instrumental configuration. The wavelength range of these spectra extends from 3200 Å to 9000 Å; the standard resolution is 10 Å. For limited spectral ranges, spectra at higher resolution, 3 to 5 Å, are being obtained in addition. Proper flux calibration of the spectra is always performed by means of bright southern spectrophotometric standard stars such as ζ Puppis or α Crucis.

This data set will certainly belong to the best available spectra of the supernova; maybe it is unique. Especially remarkable is the fact that these high-precision data were obtained with a small-sized telescope and relatively modest equipment compared to large observatory standards.

Between May and July when Supernova 1987A was below the celestial south pole all night, the 61-cm Bochum telescope turned out to be the only telescope at La Silla able to follow the supernova and to take spectra even at airmasses as large as 6 (corresponding to zenith distance 80°). For that purpose, observers had to work very close to the limit switches protecting the telescope against mechanical damage. The Bochum telescope certainly had never before been pointed at such extreme coordinates, at least not intentionally. In order to be able to look into the telescope's eyepiece without burdening the telescope axes with its body's weight, one author (R.W.H.) invented a rather unusual method for guiding the supernova: he installed a rubber rope at the dome wall and, hanging himself on the rope and balancing on top of a ladder two meters above the ground like a mountaineer, carefully moved his eye towards the eyepiece which was at some "impossible" position on top of the telescope tube.

By now, more than 300 days of Supernova 1987A have been covered observationally. The first 110 of them are depicted in a compressed manner in the accompanying figure. This plot shows the temporal evolution of the spectral fluxes of SN 1987A between 1987 February 25 and June 14.

The most obvious advantage of this compact representation is the visualization of the well-known photometric lightcurve: the flux distribution changes dramatically in the very first days due to the steep decrease of the effective temperature of the outflowing gas. After about day 10 since explosion, flux distribution remains approximately constant; the absolute flux level, however, increases steadily until, around May 20, the visual maximum is reached. Afterwards, flux decreases more rapidly.

The next obvious feature in this plot is the dramatic evolution of the Doppler shift, i.e. the decreasing velocities of spectral lines produced in the expanding envelope. The intensity minimum of the Hα absorption trough is at −17,400 km/s on February 25, falling off to −6,200 km/s by April 14 and −5,400 km/s by July 14. This general trend is already well known from other supernovae and is due to the fact that outflowing material is diluted by expansion and is assorted according to increasing velocity and decreasing density: in the expanding supernova shell, at any time velocity is proportional to distance from the centre of explosion. Therefore, expanding layers may be opaque at some time and later become optically thin, revealing lower, less rapidly expanding layers. Thus, in front of the supernova, optical lines characteristic for the most abundant elements in the supernova atmosphere (hydrogen, helium) or for particularly strong transitions (e.g., of calcium or sodium) are visible at the highest velocities towards the observer (corresponding to the lowest discernible densities in the outermost layers of the ejecta), while lines indicating less abundant constituents of the atmosphere are produced at lower velocites and higher densities. Then, as time goes on, it is possible to look deeper and deeper into the ejected atmosphere of the exploding star. So far, no indication has been detected for interaction of the ejecta with the surrounding pre-outburst material, and consequently supernova matter is still in free expansion. Decreasing velocities therefore result only from decreasing opacity of the expanding shell.

Maximum outflow velocities can be inferred from the blue edge of the absorption component of the Hα P Cygni-type profile: we measured −31,000 km/s on February 25; extrapolation back to February 23 even yields a velocity in the vicinity of −40,000 km/s as the velocity of the fastest ejecta, that is 13 % of the speed of light. These enormously high velocities are now commonly believed to be responsible for the rather unusual lightcurve of the supernova, i.e. its extremely long rise until maximum was reached at a relatively low absolute level.

Our continuous time series of homogeneous spectral measurements offers a unique opportunity for safe identification of the bewildering amount of absorption and P Cygni-type lines in the supernova spectrum. Work on line identification and radial velocity determination is in good progress.

Meanwhile, forbidden lines such as [Ca II] λ 7291/7363 Å and [O I] λ 6300/6363 Å have become visible in the supernova spectrum marking the beginning of the nebular phase. As a whole, the dramatic evolution of the optical spectrum of SN 1987A has slowed down, but certainly will provide further surprising features in the visible. Our time series will be continued as long as possible and certainly provide invaluable information about an event which happens at most once in the lifetime of an astronomer.

Acknowledgements

We are greatly indebted to our Institute Director, Prof. Th. Schmidt-Kaler, who invested a lot of time in organizing financial and personal support for the continuous observing campaign, and to the former Director General of ESO, Prof. L. Woltjer, who generously gave several months of ESO time at the 61-cm telescope to our observers.

SN 1987A (continued)

It is now one year ago that SN 1987A in the LMC exploded. Since then, this unique event has continued to fascinate astronomers and physicists. The large number of scientific meetings, TV programmes, newspaper articles, etc. about SN 1987A at the time of its first anniversary prove its popularity.

During the past three months, since the last issue of the *Messenger*, several important observations have been made public. The first unambiguous detection of γ-rays was made with the Solar Maximum Mission satellite. Accumulating data from August 1 to October 31, 1987, two spectral lines were seen at 847 and 1238 keV, respectively; they originate during the decay of Cobalt-56. The intensities corresponded to about 0.0002 solar masses of exposed Cobalt-56 at a distance of 55 kpc. No obvious changes were observed during this period. Further γ-ray observations were made from balloon experiments flown in October and November and also from a balloon which was launched in Antarctica in early January. During the three-day flight at altitude 36 kilometres, it observed the supernova during 12 hours, permitting the registration of a detailed profile of the two Cobalt-56 lines.

After a long period of rather constant emission in the soft X-ray region, the Ginga satellite observed a sudden rise of the intensity in the 6–16 keV and 16–28 keV bands during the first days of 1988. The intensity in the first of these bands more than tripled over a two-week period.

Spectral observations in the ultraviolet, visual and infrared regions continue. Recent spectra from the IUE show UV emission lines from a variety of ions, e.g. C III, N III and possibly He II and N IV. The first detection of [O III] lines has been made with the ESO 3.6-m telescope and the Cassegrain Echelle Spectrograph (CASPEC). From the 4363 Å line, when compared to the doublet at 4959 and 5007 Å, and assuming low electron density, a plas-