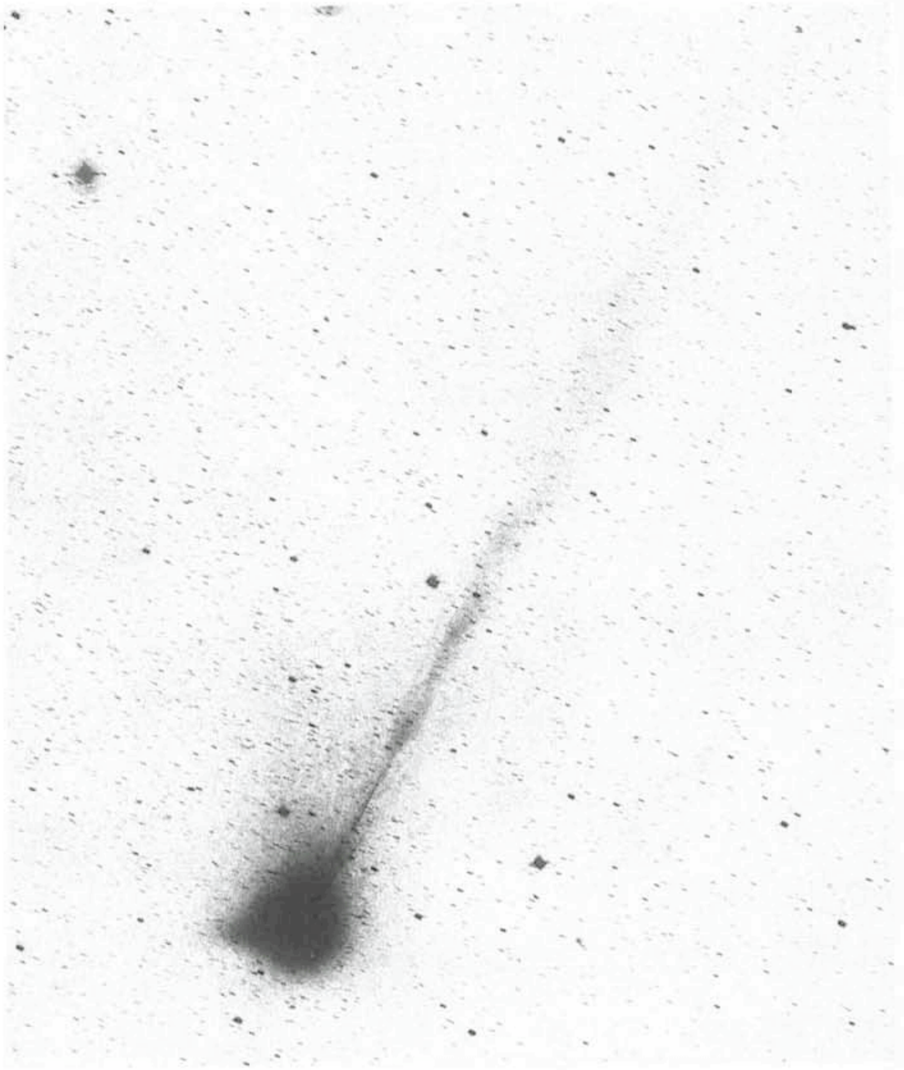
Comet Wilson Photographed from La Silla

This contrast-enhanced photo of Comet Wilson was obtained with the ESO 1-m Schmidt telescope on March 28, 1987 (30-minute exposure on IIa-O emulsion with a GG 385 filter; observers: H.-E. Schuster and G. Pizarro). This was three weeks before perihelion and the development of a long, straight ion tail can be seen. It measures about 3 degrees, corresponding to approximately 11 million km (projected) and points towards southwest. Note also the streamers near the coma. A short, stubby dust tail is seen towards north (to the left in this picture).

On this day, the distance to the Earth was 210 million kilometres. The comet was situated in the constellation Sagittarius and moving rapidly south while approaching the Earth. The magnitude was estimated at about 6.5. In early May, when the comet came within 90 million kilometres from the Earth, the magnitude was about 5. At that time, observations were made with several telescopes on La Silla; it is expected that some of the results will be reported in the next issue of the *Messenger*. Thereafter, it became fainter as it rapidly receded, and by early June 1987 the magnitude had dropped to about 7.



The Strange Supernova 1987 A Passes Maximum

The bright Supernova 1987 A in the Large Magellanic Cloud, about which initial reports were included in the *Messenger* No. 47, appears to be different from all others observed so far.

That is the unanimous conclusion of astronomers who have observed this rare object with ESO telescopes since the explosion in late February. After much hard work to meet a late March deadline, the collective, preliminary results from the ESO La Silla observatory of no less than 38 astronomers appeared in six "Letters to the Editor" in the May (I) 1987 issue of the European journal *Astronomy & Astrophysics*. They covered astrometry, optical and infrared photometry, polarimetry, optical and infrared spectroscopy and high-resolution spectroscopy. These articles have been bound together in a special Reprint which can be obtained by request to the ESO Information and Photographic Service (address on last page).

Due to its southern position. SN 1987 A cannot be observed from the northern hemisphere. A rather weak radio emission was detected in Australia during the first days after the explosion, but otherwise all astronomical observations until now have been made in UV, visual and IR light. Despite repeated efforts by satellite- and balloon-based instruments, no X-ray or gamma-ray radiation has been detected. Therefore the interpretation of this exceptional event rests heavily on measurements at a few optical southern observatories, among them the European Southern Observatory.

Light Maximum by Mid-May

More than three months of observations have now been made of SN 1987 A. Measurements of its brightness showed an initial increase to a maximum near visual magnitude 4.5 on February 28. During the next few days, the brightness dropped slightly, but after March 5, it increased again, reaching visual magnitude 4.0 in late March. The ultraviolet light was nearly constant after March 10, while the intensity increased in all other spectral regions. In the infrared, the rate of brightening was about 5 % per day in late March. The visual brightness also continued to rise and by May 10 it attained magnitude 2.8, that is about half the intensity of the Polar Star. A plateau was then reached which lasted until about May 20, whereafter the supernova began to fade slowly. By early June, it is still too early to make predictions about the future rate of decline.

The time from the initial rise to the maximum, almost 3 months, is unexpectedly long and has never been observed for any other supernova. At the distance of the Large Magellanic Cloud, and taking into account the measured foreground absorption of about 0.6 magnitudes, the maximal absolute magnitude of the supernova was about −16. This is somewhat fainter than a normal Type II supernova. From the light curve alone, SN 1987 A would therefore appear to belong to a hitherto unknown class.

A B Supergiant Exploded

Accurate astrometry at ESO in late February which was confirmed by measurements in other places, indicated that SN 1987 A's position in the sky was less than 0.1 arcsecond from where a 12th-magnitude star, Sanduleak −69 202, was seen before the explosion. It was found that this star had two nearby companions, at distances of about 3.0 and 1.4 arcseconds, respectively. None of these could therefore have been be the progenitor of the supernova. A new reduction of the IUE (International Ultraviolet Explorer) satellite data in early April indicated that these two companions were still there, but also that the central star of Sanduleak −69 202 had disappeared. Thus there is now general agreement that it must have been this star that exploded.

However, its spectral type was measured at ESO in the mid-1970s as B3 Ia, that is a hot supergiant, and according to current evolutionary theories it should not yet have reached the critical phase. Most theories predict that the supernova precursor should have been a more evolved, cool supergiant of spectral type M. For some time it was thought that an M supergiant might also have been present in the Sanduleak system, but photometry of old plates in different spectral regions soon ruled this possibility out. Theoretical astrophysicists are therefore now confronted with the problems of why and how the hot B star blew up at this stage of its evolution.

Neutron Star or Black Hole?

Continued monitoring by fast photometry at La Silla has not yet shown the existence of a pulsar in SN 1987 A, that is a rapidly spinning neutron star, supposed to be created in a supernova explosion of Type II. If there is such an object at the centre of SN 1987 A, its light must still be obscured by the surrounding, rapidly expanding envelope of material. However, some astronomers think that the neutron star which was created at the supernova explosion may have been transformed into a black hole within a few hours.

This might explain why *two* bursts of neutrinos were observed by particle detectors, early in the morning of February 23, 1987. The first event was detected at 02 : 52 UT in the Mount Blanc tunnel between France and Italy and a second event was seen at 07 : 35, simultaneously in Japan and in the USA and possibly also by an experiment in the USSR. Could it be that the first neutrino shower was emitted at the time of the initial collapse of the core, when a heavy neutron star was formed, which was too heavy to be stable, and that it collapsed into a black hole, some 4 ½ hours later? To solve this question, observations of the left-over central object and its surroundings are needed. In any case, the spread in arrival times of the observed neutrinos have already led to refined estimates of the neutrino mass. This measurement in turn has direct compact on cosmology, because of the (predicted) enormous numbers of neutrinos in the Universe.

In this connection, the very early sightings of SN 1987 A have become extremely important, in order to establish the accurate lightcurve (and thereby the temperature and expansion rate) during the first 24 hours. More photographs by Australian amateurs have recently been found and are being studied. The non-sighting of the supernova in the morning of February 23 by Mr. A. Jones, an experienced amateur astronomer in New Zealand, has taken on new significance and the corresponding upper limit to the brightness may be crucial for the correct interpretation of the neutrino events. It is interesting to note how amateur observations with simple and inexpensive means contribute to the highly sophisticated and expensive particle physics experiments!

The Envelope Expands

Infrared observations showed that the temperature of the expanding envelope was 5,800 K on March 1; on this day, the diameter was 5,600 times the diameter of the Sun, that is almost equal to the size of the orbit of planet Neptune. Ten days later, the temperature had dropped to 5,200 K and the diameter of the envelope had grown to 9,100 times that of the Sun. The expansion velocity fell from initially 18,000 km/sec to about 10,000 km/sec in late March and to 5,000 km/sec by mid-May.

In late March there were signs of some extra light in the far infrared (12 μm), possibly because the strong light from the supernova was being reradiated by surrounding interstellar dust ("infrared echo"). However, infrared speckle interferometry with the ESO 3.6-m telescope on May 8 and 9 did not show any extended emission (≥ 0.3 arcsec), but the weather conditions were not optimal for this kind of work. However, speckle observations in visible light with the AAT and Cerro Tololo 4-m telescopes in late April and early May indicated the presence of an (emission line?) object, only ~ 0.06 arcsec almost due south of the supernova, and ~ 3 magnitudes fainter. The nature of this object is still unknown and a detailed investigation must await the time when the supernova has become significantly fainter.

In the beginning, the spectrum of the supernova changed rapidly, in fact much faster than any other supernova observed so far. Only 20 days past maximum, the optical spectrum already resembled that of a Type II supernova, when it is 100 days after maximum light. Also for this reason, most astronomers expressed doubt whether SN 1987 A can be classified as Type II. From early May onwards, the spectra showed more and more features, suggesting that the surrounding envelope was breaking up into smaller pieces and filaments.

Intervening Clouds

No less than 24 narrow absorption line systems were detected in very-high resolution spectra of SN 1987 A, obtained with the Coudé Echelle Spectrometer at the 1.4-m CAT at La Silla. They originate when the light from the supernova passes through interstellar clouds in the LMC and in our Galaxy, and also through clouds in intergalactic space between them. The presence of Calcium, Sodium and Potassium was observed and also Lithium-7. This is the first time ever that neutral Lithium, Calcium und Potassium have been detected in interstellar space outside the Galaxy.

ESO Workshop on July 6–8, 1987

The observations at La Silla will continue as long as possible. It is of course not possible to predict how rapidly the brightness is going to decline, but nobody doubts that SN 1987 A will be followed as long as possible. In this connection, however, observations will become difficult when the brightness drops below magnitude 13, because of interfering light from the close companions, mentioned above.

Meanwhile ESO is now preparing for the first full-scale international meeting about "SN 1987 A in the LMC", which will take place at the ESO Headquarters in Garching bei München, on July 6–8, 1987. More than 100 supernova specialists from all continents intend to participate. The topics will include all aspects of supernova research, from the precursor star to the evolution of the envelope and interaction with the surrounding interstellar medium. The outcome of this important meeting will be reported in the next issue of the Messenger. *The editor*

This colour photo is a composite of three black-and-white photos taken with the ESO 1-m Schmidt telescope on February 27, 1987, four days after the explosion of SN 1987 A. The supernova is the bright star to the right; the cross is an optical effect in the telescope, caused by the plateholder support. Most of the fainter stars in this picture belong to the Large Magellanic Cloud. The bright nebula left of the supernova is 30 Doradus, also known as the Tarantula Nebula, due to its shape.