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.

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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 plasma temperature of 40,000 K was computed. These lines are very narrow and their velocities are near 285 km/sec, indicating that they may originate in a circumstellar shell (ejected from the progenitor during an earlier mass-loss phase?)

A long-term programme is under way with the Bochum telescope on La Silla; see the article by Hanuschik et al., in this *Messenger* issue. In the far-infrared spectral region, several flights with the Kuiper Airborne Observatory (KAO) have showed emission lines from iron-group elements, synthesized during the supernova explosion. SN 1987A continues to be radio-quiet and the longest wavelength at which it has recently been detected is 95 μm.

Speckle interferometric observations with the 4-m telescope at the Cerro Tololo Inter-American Observatory in November have resolved the supernova shell at about 0.02 arcseconds, corresponding to a mean velocity of about 4,000 km/sec since the explosion. Similar observations with the 4-m Anglo-Australian Telescope, also in November, show that if there is a secondary object within about 0.8 arcsec of SN 1987 A, then it must be at least 4 magnitudes fainter.

The supernova faded to magnitude 6.4 in mid-January and to about 6.8 in mid-February. After a period of linear decline on the magnitude scale, corresponding to the radioactive decay rate of Cobalt-56, the decline became more rapid. Towards the end of January, observers at the South African Astronomical Observatory found that the bolometric (total) luminosity was 7 % below a straight extrapolation from the linear decline between July and October 1987. The light in the U-band which had been constant over a long period, again started to fade in late December 1987.

The Editor (February 23, 1987)

Some Prospects of Galactic and Extragalactic Studies*

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The main purpose of the astronomical work is to obtain information about all kinds of bodies and systems existing in the Universe, about their past and future, and regularities of processes going on in them. Studies and the observational work with this purpose are developing in three main directions: the study of the Solar system and of its members (planets, comets, meteorites), the galactic research which studies our stellar system and its members (stars, nebulae, clusters of stars), and the extragalactic research.

Since the discoveries of Galileo, astronomers have applied and continue to apply optical telescopes in all three directions mentioned above. However, during this century new methods have been invented. It is sufficient to mention here the ground based radio telescopes, the X-ray receivers and telescopes, γ-ray receivers which are observing from the space around the Earth. But, of course, the recent technical progress has affected in the strongest degree the planetary astronomy. Some of the space vehicles give us the possibility to observe the planets, comets, satellites from the immediate vicinity. There is no doubt that the role of investigations with space vehicles in planetary studies will enormously increase in future and this means that the role of ground based telescopic observations in this field will diminish.

Of course, in the fields of galactic and extragalactic research the modern methods (radio astronomy, X-ray astronomy, far infrared, space missions and particularly space interferometry in different wavelengths) will play an increasing role, but they cannot replace, at least during the next several decades and probably during the next century the work of optical telescopes.

Therefore, let us concentrate our attention on galactic and extragalactic research, though we must not forget that the solar-system studies can have a great indirect influence on the studies of phenomena on the stellar and galactic scale.

What is the main purpose of astronomical research in the galactic and extragalactic fields?

I think it is (1) to understand the constitution of stars and nebulae as well as of systems, including the increasing volume of the Metagalaxy and (2) to study the origin, life, evolution and the future destiny of these bodies and systems.

This is the general formulation of goals of these fields of science. However, in the practice of scientific work these general goals dissolve into countless subjects, problems, questions and topics, each of which can prove its importance and can require a special programme of studies.

And you know well that very often the solution of each problem raises a large number of new problems, which in the past were under the scientific horizon.

The difficulty of formulating the multitude of special problems, of programming the ways of their solution is complicated by the fact that they very often intersect and penetrate each other.

Let us take one example. Everybody understands that we have two important and seemingly independent problems of stellar astronomy: the distribution of the stars in the Galaxy and the origin of stars. By studying the distribution of early-type stars in the Galaxy we arrived at the concept of OB associations, and the nearer study of OB associations has brought us nearer to the solution of the origin of early-type stars. In the same way the study of the distribution of dwarf variables of T Tauri and RW Aurigae stars has immediately demonstrated us the existence of T associations. From this the concept of the origin of stars in groups has followed.

Inversely, the understanding of the fact of desintegration of stellar associations has opened many questions on the kinematics of open clusters and individual stars which are the *remnants* of stellar associations.

Thus there are two problems: the origin of stars and their distribution in the Galaxy, and they are closely connected.

On the other side, the observations show that the formation of stars in the association is taking place in smaller subgroups in the, so to say, *recent star formation regions* which have linear sizes smaller than one parsec and comprise only a very small part of the volume of the associations.

The study of such regions where the complicated phenomena of the ejection of gaseous matter, of H_2O and other masers, as well as the formation and ejection of Herbig-Haro objects are characteristic is to be carried out with many different techniques, among which optical and infrared telescopes are playing an important part.

Last Wednesday Dr. Moorwood showed us some infrared pictures of such a region in Orion where the Becklin-Neugebauer object and other infrared sources are situated.

We are sure that the study of these phenomena will bring us much nearer to

* Talk given at First School for Young Astronomers Organized by ESO and the Astronomical Council of the U.S.S.R. Academy of Sciences (see the *Messenger* **50**, p. 43–44).