THE MESSENGER

EL MENSAJERO

No. 19 – December 1979

The Dutch Telescope on La Silla

J. Lub

> *Welcome to La Silla!*
>
> *As the latest newcomer in the family of telescopes at ESO, the Dutch 90 cm "Lightcollector" has now been installed and, as expected, it performs very well in its new environment. Dr. Jan Lub from ESO/Chile is in charge of this instrument and reports about its transfer from the African to the South American continent. His article also contains important information for all prospective users.*

The 90 cm photometric telescope of the Leiden Southern Station, better known as the *Lightcollector,* was transferred from South Africa to Chile during the fall of 1978. When, on December 1978, the agreement between ESO and the Stichting Leids Sterrewacht Fonds, owner of the *Lightcollector,* was signed in Leiden, the telescope had already arrived on La Silla. The same team responsible for its dismantling in September 1978, viz Messrs. A. de Jong and G.v.d. Nagel of the Leiden workshop and D.F. Stevenson, electronician and manager of the Leiden Southern Station, also took care of the reconstruction of the telescope and its peripherals. They could start work by mid-January 1979 in the old 1 m dome (also known as the *Chilimap* dome) and the project was substantially finished during the first days of March. Simultaneously ESO had an extension to the dome constructed in order to provide some office and storage space. After the final astronomical tests of telescope and equipment by Dr. J.W. Pel (Roden) and the author, regular observations could be started again by the end of March after an interruption of less than seven months! Unfortunately this was just at the end of the good period. Figure 1 shows the telescope (in sunlight) in its present state.

The Telescope

Over the years the site in South Africa on the Republic Observatory Annexe at the Hartebeespoortdam, where the telescope was first erected in 1958, had considerably deteriorated. This was mainly caused by pollution from the nearby big cities of Pretoria and Johannesburg. The discussion to look for a new site had been going on for some time in Leiden and it was finally concluded that the best solution would be to seek from ESO an arrangement such as that already existing for the Danish national telescopes. An important consideration was here the near equality of the latitudes of Hartebeespoort (–25°46') vs. La Silla (–29°15'). This would require that a new pillar would have to be only slightly inclined.

ESO and the Dutch astronomical community will each have access to 50 % of the available time, evenly distributed over the year. It is hoped that the presence of the *Lightcollector* will take some pressure off the heavily oversubscribed ESO 1 m photometric telescope.

The telescope and its control-and-drive system were built by Rademakers (Rotterdam) and the Leiden workshop in 1955. It can be considered as a prototype of the well-known ESO 1 m telescope. Some technical/optical data are collected in the table below.

Lightcollector Technical Data	
Cassegrain fork mounting	
Dall-Kirkham optics	
Primary diameter:	90.8 cm
Secondary diameter:	24.9 cm
Overall focal ratio:	F/13.8
Usable (uncorrected) field:	5′
Setting speed:	100°/min
Pointing accuracy:	20″
Clearance in fork:	83 cm
Maximum weight of instruments	~ 100 kg

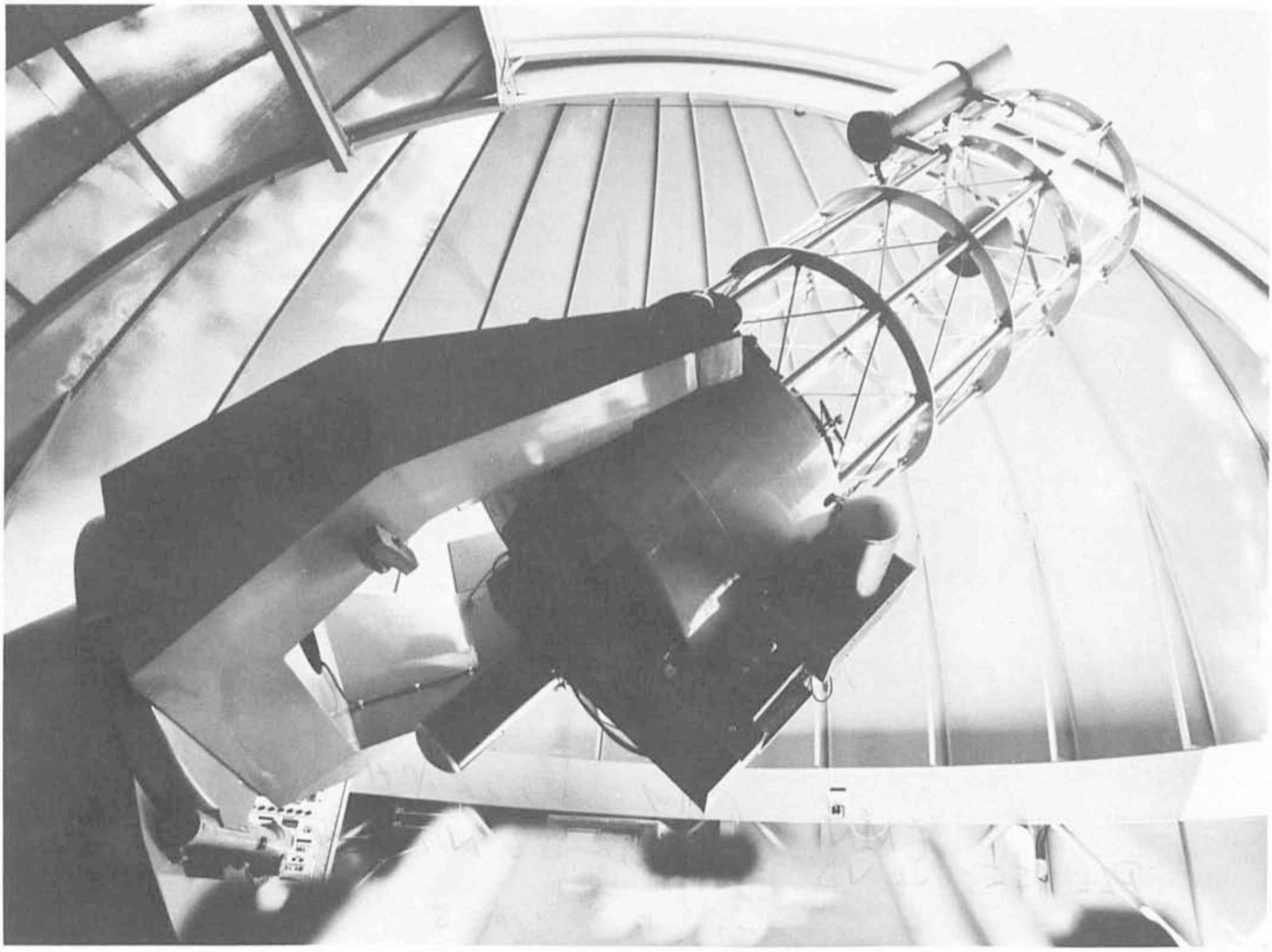

Fig. 1: *The Lightcollector.*

An important design consideration has been to provide a fast, accurately pointing and efficient telescope. These expectations it has amply fulfilled during more than 20 years of service in South Africa. The telescope control is particularly convenient in that coordinates can be preset on a set of dials while a measurement is going on. When it is finished, the telescope will move automatically to the new position. The mechanical functioning has been rather smooth up to now on La Silla.

The Walraven Photometer

Since 1958 the *Lightcollector* has been mainly used with its standard instrument: the five-channel simultaneous Walraven photometer. As can be seen in figure 2 this photometer looks as if it were built around the telescope. The principles of this spectrophotometer have been first described by the Walravens (Walraven, Th. and Walraven, J.H., 1960, *Bull. Astron. Inst. of the Netherlands,* **15,** 67). The data-acquisition system is still largely the same as described by Rijf, Tinbergen and Walraven, 1969, *Bull. Astron. Inst. of the Netherlands,* **20,** 279, with the provision that since 1975 the data are no longer recorded on paper tape but on two cassette-units. We also refer to their paper for further technical details, which would lead us much too far here, and urge prospective users to carefully read their work.

We now briefly describe the working of the photometer (see figure 2 for the general layout). The light first passes a turnable prism which deflects it either towards the eyepiece or towards the photometer. In the latter case, the light passes through the beamsplitter which makes two complementary beams of light and dark bands. One beam then passes through two quartz prisms, dispersing the light and deflecting it upwards along the telescope tube and is then imaged by the condensor. The resulting spectrum is cut at the dark bands by little prisms to give four photometric bands: V, B, U, W, and then reaches four photomultipliers, two on each side of the spectrograph, mounted in dry-ice-cooled dewars. In this way seeing variations do not have any influence upon the form of the passbands. Moreover, the light efficiency is very high due to the use of quartz elements (especially important in the ultraviolet). The second beam is deflected downwards into a third dewar. Using a glass filter the photometric L-band is selected.

During the transport of the telescope from South Africa to Chile, the photometer was flown back to Holland, where Dr. J.W. Pel and the Roden workshop carried out a long-needed revision. The lower part of the photometer was made easily removable, whereas the part along the telescope tube was restructured so that it will remain forever attached to the telescope and needs no realignment. In this way it will be easy to accommodate other instruments at the Cassegrain focus. Dr. Pel also recalculated the optical light-path in the instrument and this proved highly useful when the whole photometer was realigned on La Silla using a laser. Measurements and calculations showed perfect agreement.

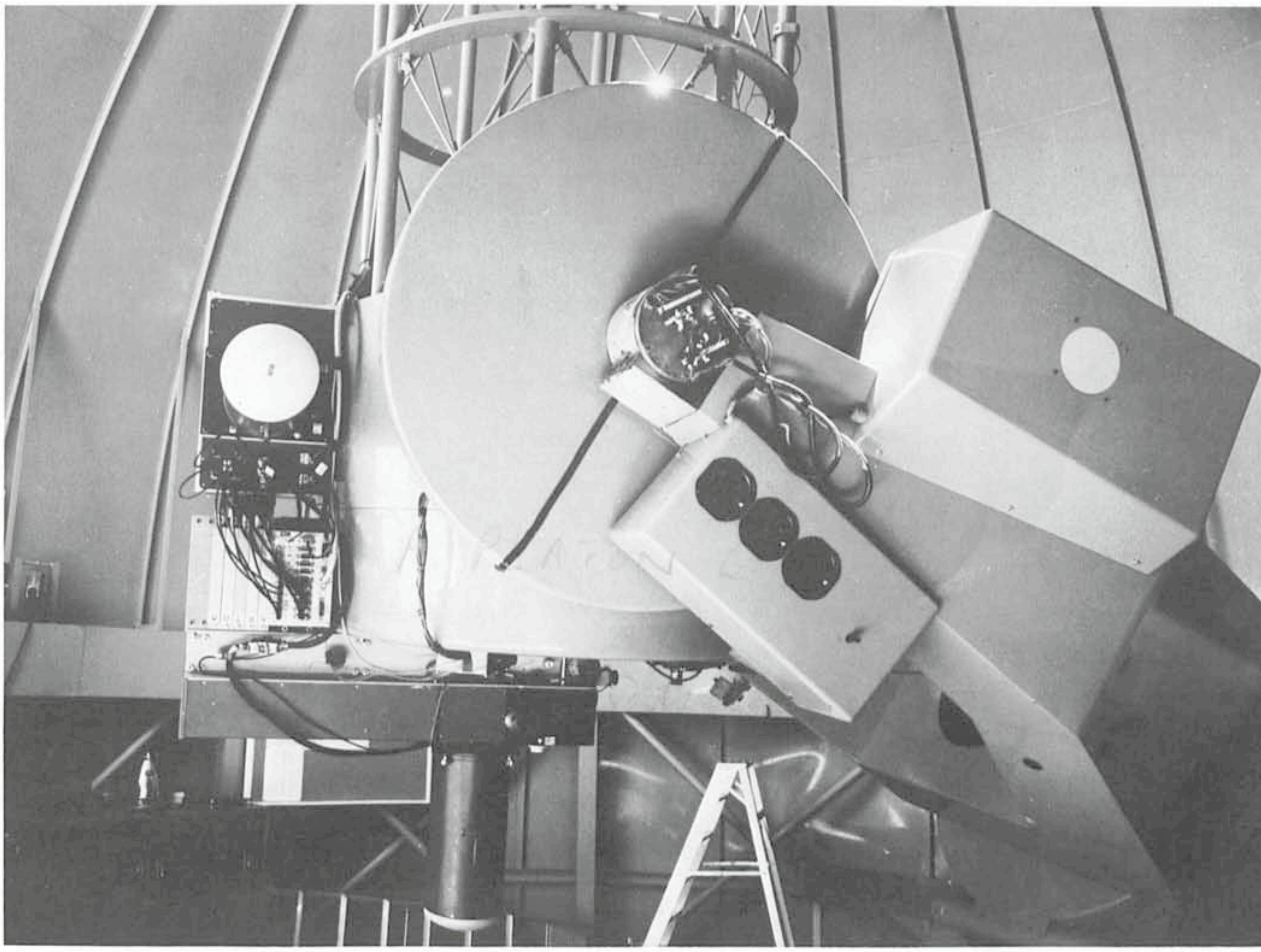

Fig. 2: *The Walraven photometer. One sees the L-form of the photometer. The dewar containing the L-photocell sticks out below and the one containing the B–W-photocells protrudes forward. The eyepiece is directly below the telescope axis. Further visible are declination motor and worm.*

The data acquisition is based upon a DC-mode operation. To each photomultiplier there belongs one integrator which incorporates a set of three auto-ranging condensors. When a measurement is finished these five integrators are read out sequentially by a digital voltmeter. Each measurement normally consists of two such integrations; in between and afterwards the integrators are shorted automatically. This causes a delay of at most 4 seconds, so that this is a kind of minimum useful integration time. For very bright stars a mechanical optical attenuator—a rotating drum with slots—can be introduced into the light beam giving roughly 3^m attenuation. In this way a dynamic range of 2^m to 15^m is assured. The system is capable of an overall accuracy of 1‰. Reduction of the measurements is at present only possible in Leiden; facilities have been made available to ESO observers (contact Dr. J. Tinbergen, Sterrewacht, Leiden).

Telescope Performance on La Silla

With new and more sensitive photomultipliers (Hamamatsu R928 S-20 sidewindow, replacing the 20(!)-year-old set of IP21), freshly aluminized mirrors and the better transparency on La Silla, a substantial gain in sensitivity, especially in the ultra-violet, was predicted. This agreed with the author's extensive tests in April. All these improvements have slightly changed the photometric passbands as published by Lub and Pel (*Astron. Astrophys.*, **54**, 137, 1977), the new values are summarized below in table 1. These data were determined in two ways: first from the known properties of the beamsplitter (Pel and Lub, in preparation) and, second, by scanning through the spectrum with a narrow slit. From stars of known absolute energy distribution and a range of spectral types one can then determine the zeropoints of transmission from the spectral features visible. Agreement exists to within a few Ångstroms between both methods. As an illustration of the high transparency on La Silla I mention that we still measure quite some flux at 3100 Å.

Relative transmission	V	B	L	U	W
0	(6600)	4783	(4190)	3894	3398
1/2	5783	4494	3952	3735	3313
1	5413	4262	3845	3614	3232
1/2	5078	4062	3738	3504	3157
0	4783	3894	3616	3398	3073
λ_{eff}	5422	4270	3845	3617	3234
Band-width	705	432	214	231	156

Table 1: *The present Walraven pass-bands as determined by Lub and Pel (La Silla, March 1979). All wavelengths are in Ångstroms.*

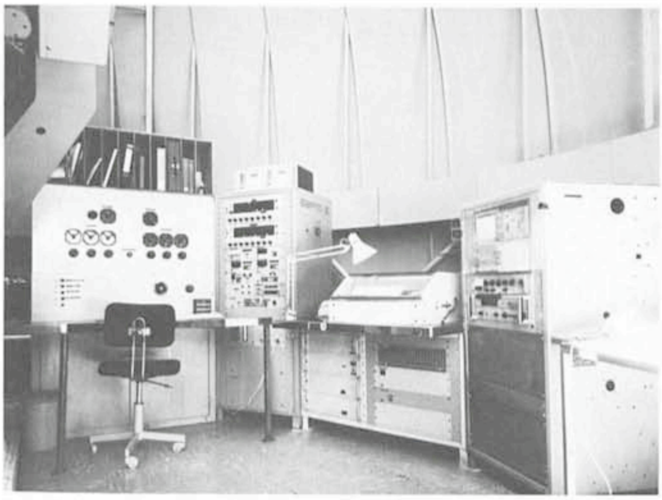

Fig. 3: *Overview of telescope control and data acquisition. To the left the telescope controls; in the middle the data-acquisition rack—on top of which the two cassette-units—and the IBM typewriter/printer.*

The filter system was conceived by Dr. Walraven in order to be able to measure properties of the continuous and line spectrum in stars of spectral type O to middle G which relate directly to effective temperature and surface gravity and, as it turns out, also to heavy-element-line blanketing. The central wavelengths of his five bands were chosen to match the well-known Paris (or Barbier-Chalonge-Divan) classification based on spectrophotometry on photographic spectrograms. Not surprisingly, the possibilities with the VBLUW or Walraven system are in many ways the same as with the well-known Strömgren uvbyHβ system. I refer to the above-mentioned paper by Lub and Pel for more details. Important applications have been to pulsating variable stars (Pel, Lub); the highly luminous OB supergiants in the Magellanic Clouds (Walraven and Walraven) and X-ray binaries (van Genderen and van Paradijs). References may be found in my paper in the 1979 Albany Workshop on *Problems of Calibration of Multicolour Photometric Systems,* edited by A.G. Davis Philip, Dudley Observatory Report No. 14.

I hope to have given a flavour of the possibilities of the present instrumentation on the Dutch telescope. Before long, ESO will install a computer, tape unit and fast printer for faster data acquisition and, possibly, on-line reduction. However, the complete reduction, including the analysis of the linearity of the digital voltmeter still has to be done in Leiden. During 1980 ESO will construct a (high-speed) one-channel photometer for the standard photometric systems such as UBVRI (Cousins) or uvbyHβ. Compatibility with other equipment on La Silla will be assured. Until this is finished the Walraven photometer is the only instrument available to visitors.

Acknowledgements

We wish to thank the Board of Directors of the Stichting Leids Sterrewacht Fonds for permission to give new life to the *Lightcollector* on La Silla. We would like to mention in particular the support given by Prof. A. Blaauw and Dr. J. Tinbergen of Leiden Observatory. The collaboration of Messrs. A. de Jong and G.v. d. Nagel during the reconstruction phase was always a great pleasure; they cheerfully and ably solved all arising small mechanical problems. Dr. J.W. Pel did a fantastic job on the photometer and the optics. ESO staff did as much as they could to provide additional support.

28 Canis Majoris—a Short-period Be Star

D. Baade

Are Be stars nothing but β Cephei stars? This far-reaching possibility is supported by new observations of the Be star 28 CMa, which shows spectral variations with a period of 1.36 days. Dr. Dietrich Baade of the Astronomical Institute of the University of Münster, FRG, recently obtained spectra of this star with the large coudé spectrograph at the ESO 1.52 m telescope. Here is his report about this important discovery.

Among the confusing variety of stars with unusual properties, Be stars probably form the group with the largest number of known members. This is in part due to their high intensive brightness. But the fact that 10 to 15 per cent of all non-supergiant stars of spectral type B exhibit emission lines also shows that the Be phenomenon is important. Moreover, Be stars are quite attractive objects for observations, since most of them undergo unpredictable spectral and photometric variations, which in some cases are fairly drastic. Nevertheless, Be stars are far from being understood.

Some Empirical Aspects of Be Stars

The main reason for this lack of comprehension is exactly the irregularity in the behaviour of nearly all Be stars. Thus, observations of individual stars normally are not expected to contribute much to the improvement of models for Be stars. Only statistical treatment made it possible to derive several types of variability representative for the Be phenomenon. Erratic long- and short-term photometric variations with amplitudes up to several tenths and a few hundredths of a magnitude, respectively, are common. Most important, however, are the spectroscopic changes, among them the characteristic V/R variations, i.e. the changing relative equivalent widths of the blue and red components of double-peaked emission lines.

V/R variations are in many cases cyclic but not strictly periodic. The duration of a (long) cycle differs from star to star within the range of 100 days to several years. The longer the cycle, the fewer cycles occur before the variation ceases gradually or abruptly. Short cycle lengths in the range of minutes or even seconds are reported for an increasing number of stars. They are, however, even less stable and have in no case been confirmed by a second series of observations.

Only one other type of variability of Be stars is correlated with the V/R variations: the radial velocities (RV) of the emission lines and their central reversals. But their interpretation is rather doubtful, and it cannot be ruled out that the RV variations are simply observational consequences of the V/R variations.

Effects on Models for Be Stars

The numerous irregularities and the, nevertheless, marked uniformity of the observations, if only the few properties common to the great majority of Be stars are considered, make their interpretation quite uncertain. Hence there are few observational restrictions for model building on the basis of the V/R variations and consequently a great variety of such models has been suggested—double star, elliptical ring, radial pulsation, stellar wind, ... A convincing decision between different models is seldom possible, since contradictions between models and observations can only be found in a few cases. An additional disadvantage of some of these models is that they put the origin of the variability into the shell or extended atmosphere of the star rather than into the star itself.

Observations of 28 Canis Majoris

With an average visual magnitude of $m_v = 3^{m}_{.}8$, 29 ω CMa (B2 IVe) belongs to the apparently brightest Be stars. It is largely due to this circumstance that its very remarkable variability has been detected. Because of the short exposure time (5 minutes on baked IIIa-J plates, 12 Å/mm) at the coudé spectrograph of the 1.52 m telescope, I obtained in November 1976 within 6 nights more than a dozen spectra of this star in addition to an extensive observational material on a large number of other stars. When I was back in Münster and measured the radial velocity of the star it turned out to be variable due to an unusual circumstance. The reason was not a shift of the entire lines but a changing asymmetry in the moderately broadened ($v_{rot} \sin i \approx$ 100 km/s) profiles of *all* absorption lines (cf. fig. 1). This was connected with a weak V/R variation of the emission lines HI and FeII). Such observations are not known for Be stars: even similar ones of other stars are extremely scarce. The time scale of this variability was less than a few days.

These findings are remarkable (1) because they reveal a new phenomenon correlated with the V/R variations and (2) because they place the time scale of the variability of 28 CMa into the large gap between the observed spectroscopic cycle lengths of several minutes to a few hours and 100 days.

Another observing run, which was conducted in January 1978 by Dr. Duerbeck, Bonn, using the same equipment, confirmed the preliminary results and added considerable detail. The most important outcome is the strict periodicity of all variations with a period of $P = 1^{d}_{.}36$. This period has probably been stable over more than 9 years, since it was also found from an examination of 6 ESO spectra taken by Prof. Van Hoof, Leuwen, and kindly lent to me. It is by far the shortest stable period so far observed in Be stars.

There are many further details, which are quite interesting, but only a selection can be presented here. To avoid a lengthy description the reader is referred to figure 2. Note that the radial velocity curves of absorption and emission lines are 180 degrees out of phase.

Observations with the ESO 50 cm telescope as well as earlier measurements of other authors show that 28 CMa does not display night-to-night variations exceeding $0^{m}_{.}03$ in the uvby passbands. A correlation to the spectroscopic period has not been found.

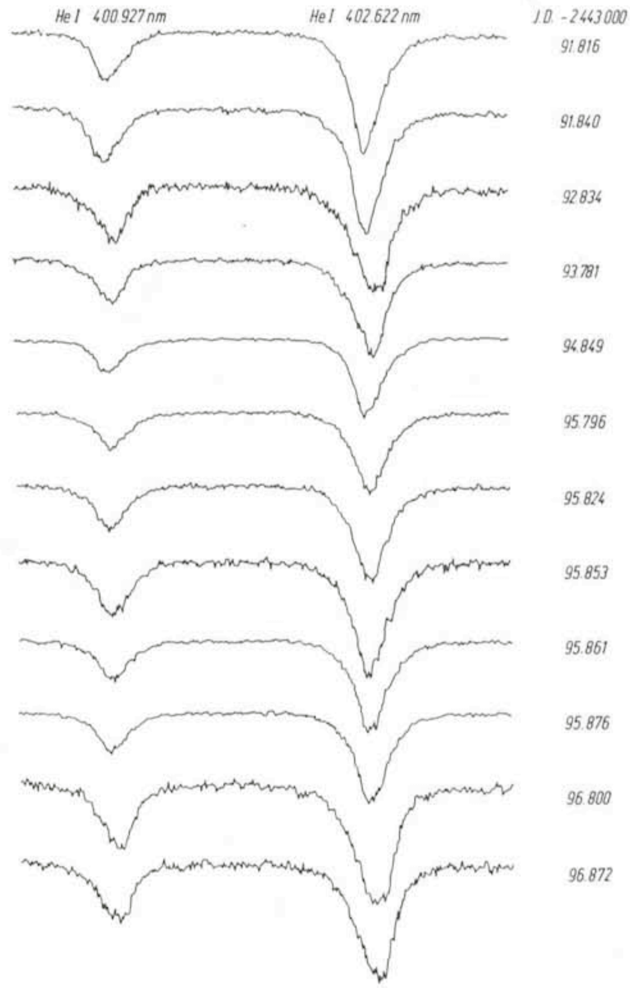

Fig. 1: *Variability of absorption lines in the spectrum of 28 CMa with time. As typical representatives the He I lines near 4009 and 4026 Å are shown.*

The Interpretation

It can be shown that all above-mentioned models of Be stars lead to unsurmountable difficulties, when used to explain the observed variability of 28 CMa. This is mainly due to the short period, the asymmetric line profiles and the missing photometric variability. On the other hand, the sequence of line profiles shown in figure 1 resembles very much those of β Cephei stars. This small group of stars is the only one in the immediate vicinity of Be stars in the Hertzsprung-Russell diagram, which shows a well-defined type of variability. A connection between Be stars and β Cephei stars has, therefore, sometimes been suggested, though observational evidence was never found. Now it seems possible that 28 CMa constitutes the "missing link".

β Cephei stars are nonradially pulsating stars with fundamental oscillation periods of 4–6 hours. If they and 28 CMa have similar internal structures, one should expect a similar period for 28 CMa. And indeed, under the assumption that 28 CMa undergoes nonradial pulsations of the P_2^2-type this can be shown to be true. The expression P_2^2-pulsation symbolizes a double wave which is symmetric with respect to the equator and travels azimuthally along

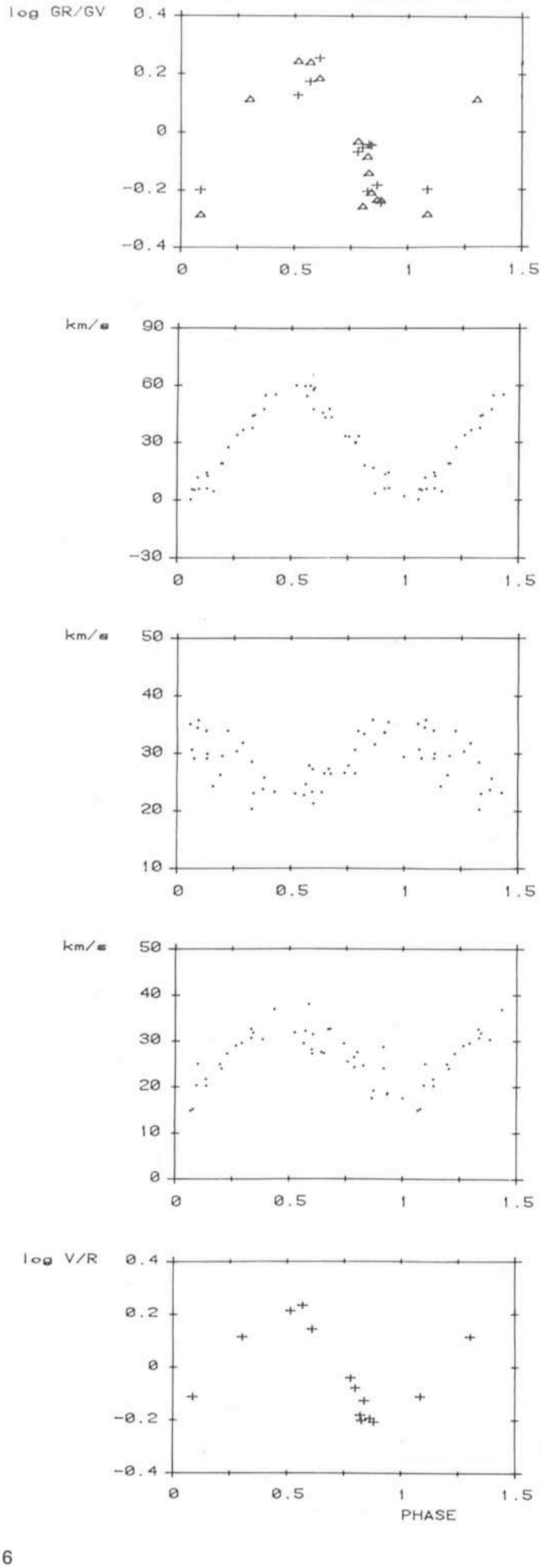

Fig. 2: *The principal spectral variations of 28 CMa: (a) ratio of the gradients of the red (GR) and the violet (GV) wings, crosses: He I 4009 Å, triangles: He I 4026 Å, (b) RV curve of the He I singlets, (c) RV curve of the total emissions in Hβ and Hγ, (d) RV curve of the central reversals of the emissions in Hδ to H10, (e) V/R ratio in Hδ.*

the stellar surface in opposite sense to the direction of the stellar rotation. It is this direction of propagation of the waves which, together with the rotation, makes the actually observed period of the star appear longer than the one which would be observed in the rotating frame of the star.

The travelling wave itself is the cause of the variable asymmetric absorption-line profiles. Furthermore, since its velocity of propagation exceeds the speed of sound in the stellar atmosphere, an additional emission produced in the wake of the corresponding shockwaves can account for both, the V/R variation and the variable radial velocity of the total emission of a given line. The V/R variation is probably strengthened by the 180 degree phase shift between the RV curves of the emissions and the central reversals (cf. fig. 2).

A Few Conclusions

Keeping the "corotating" period constant, calculations show that the observed period is very sensitive to even small differences in stellar rotational periods and radii. With other words, one can expect for different stars periods as short as the one of 28 CMa or shorter and others which are longer, up to many years. Thus the explanation of the behaviour of 28 CMa provides an interesting working hypothesis for additional future examinations of other Be stars. In particular, nonradial pulsations may enable a Be star—in connection with its high rotational velocity—to maintain its envelope.

To verify nonradial pulsations in Be stars spectroscopically may be somewhat difficult because of the generally strong rotational broadening of their spectral lines. On the other hand, one is encouraged by the increasing number of known line-profile-variable B stars in all luminosity classes. This leads to the supposition that a surprisingly high fraction of all early-type B stars undergoes nonradial pulsations. Therefore, the observations of 28 CMa, which are until now in several aspects more or less unique for Be stars, will hopefully contribute to overcome the isolation of Be stars from other stars, which is probably a major reason for the above-mentioned, current unsatisfactory situation of the investigation of Be stars.

List of Preprints Published at ESO Scientific Group

September–November 1979

68. L. WOLTJER: High Energy Astrophysics and Cosmology (IAU Proceedings). September 1979.
69. G. CONTOPOULOS: The 4:1 Resonance. October 1979. *Celestial Mechanics.*
70. E. ATHANASSOULA: Bar-driven Spiral Structure. *Astronomy and Astrophysics.* October 1979.
71. J. MATERNE: Mass-to-light Ratios of Nearby Groups of Galaxies. *Astronomy and Astrophysics.* October 1979.
72. J. BREYSACHER and N. VOGT: Spectroscopy of Ex Hydrae. *Astronomy and Astrophysics.* November 1979.

Red Stars in Nearby Galaxies

B. E. Westerlund

The study of the very cool stars in our Galaxy and in other galaxies is of great importance for our understanding of galaxy evolution. The first step in such an investigation is to identify these stars among the numerous warmer ones. Various search techniques are available and are here described by Professor Bengt Westerlund from the Uppsala Observatory in Sweden and formerly ESO Director in Chile. In particular, the new GRISMs at the prime focus of the 3.6 m telescope allow the detection of even very faint M, C and S stars. The extremely promising results of the initial observations are discussed by the author.

Detection of Cool Stars

Low-dispersion objective-prism spectra have been used for about 30 years for the detection of cool red stars in our Galaxy. Nassau and van Albada (1949: *Ap. J.*, **109,** 391) introduced the method of using the near infrared spectral range (6800–8800 Å) for the detection and classification of M stars by their strong TiO bands and by the VO bands appearing in the late M types. Nassau and his collaborators also showed that carbon stars may be identified by their pronounced CN bands at 7945, 8125 and 8320 Å and S stars by the appearance of LaO bands at 7403 and 7910 Å. These features may all be seen in spectra of very low dispersion; normally dispersions in the range 1400–2400 Å/mm are used, but late-type giants have been studied in dispersions as low as 6700 Å/mm. The advantage of using low dispersion is obvious: faint limiting magnitudes may be reached without having too many overlapping spectra even in rather crowded regions of the Milky Way.

Near-infrared spectral surveys of the northern part of the galactic belt were carried out at Cleveland by Nassau and his collaborators to a limiting magnitude of about I = 10.2 mag, and the distribution of M, C and S stars has been discussed in a number of papers. An extension towards southern declinations was carried out by Blanco and Münch. A complete survey of the southern Milky Way, covering a belt of ±5° along the galactic equator, was carried out by Westerlund with the Schmidt telescope of Uppsala Southern Station at Mount Stromlo Observatory to a limiting magnitude of I = 12.5. In the longitude range l = 235° to l = 7°, 1,124 carbon stars were identified (1971: *Astr. Astrophys. Suppl.*, **4,** 51) and 74 S stars (1978: *Astron. Astrophys. Suppl.*, **32,** 401).

A number of galactic regions, northern as well as southern, have been studied in detail to limiting magnitudes of about I = 13–13.5. On the basis of the surveys and the detailed studies of selected regions, a number of conclusions may be drawn regarding the distribution of the various classes of red stars. The carbon stars and S stars found in the near-infrared surveys (the coolest of these classes) belong to the disk population and are most likely spiral-arm objects. Also the early M-type stars show clusterings with preference for spiral-arm regions. The late M-type stars are more evenly distributed. Their density increases appreciably as the galactic centre is approached.

It should be noted that the near-infrared objective-prism technique does not permit a direct luminosity classification. In surveys of the type described above few red dwarfs are expected, however, and also M supergiants are rather rare. The latter may be rather easily identified in the more detailed investigations: their colours are as a rule extremely red(dened) for their apparent magnitudes.

Cool Stars in the Magellanic Clouds

It is obviously of great interest to apply the near-infrared objective prism technique to the study of our nearest neighbours among the galaxies, the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC). This was first carried out by Westerlund (1960: *Uppsala Ann.*, **4,** No. 7; 1964: IAU Symp. No. 20, 239), who identified a large number of M-type supergiants and giants as well as several hundred carbon stars. The plate material had been obtained with the Uppsala Schmidt telescope of Mount Stromlo Observatory; with the dispersion used, 2100 Å/mm, the limiting magnitude was about I = 13.5 for a 90-min exposure on hypersensitized Kodak I-N plates. The carbon stars found were generally very close to the plate limit, as were many of the M giants. Attempts to find red stars of these classes in the SMC were not successful with this telescope; presumably it was not sufficiently powerful. The division of the M stars into supergiants and giants is in the case of the LMC primarily based on their spectral types and apparent magnitudes. The stars classified as supergiants are all of early M type, M0–M4, and have apparent magnitudes brighter than I = 12. The giants are of spectral types M4–M7 and have I > 12. Stars brighter than I = 9 were considered as galactic objects. It is probably unavoidable that a few foreground M stars appear among the Magellanic ones in the catalogues, but they should be few.

At the time of detection there was little or no possibility to confirm the memberships of these stars of the LMC. For this, larger telescopes and more sensitive detectors had to become available. Now, a large number of M stars have been observed with slit spectrographs by Roberta Humphreys (1979: *Ap. J. Suppl. Ser.*, **39,** 389) and by Westerlund and collaborators (unpublished) and the supergiant nature of the bright M stars in the LMC has been confirmed. Also, the identified possible carbon stars have been confirmed as of this type by extensive spectroscopy and photometry by Richer, Olander and Westerlund (1979: *Ap. J.*, **230,** 724).

An additional class of carbon stars has been shown to exist in the LMC by Sanduleak and Philip (1977: Publ. Warner & Swasey Obs. **2,** No. 5). With the thin prism on the Michigan Schmidt telescope at CTIO, Kodak IIIa-J plates were exposed and gave spectra covering the range 3300–5400 Å. Carbon stars were then identified by their Swan C_2 bands at 4737 and 5165 Å. In their catalogue there are about 400 stars not identified in the near infrared. Sanduleak and Philip suggested that they are hotter carbon stars, not showing sufficiently strong CN-bands in the near infrared to have been detected by us. The detailed study by Richer et al. referred to above has confirmed this.

The Schmidt telescopes permit large fields to be surveyed for cool stars rather rapidly with the methods just described. The limiting magnitudes of these surveys are, however, rather bright for extragalactic studies and the scale of the Schmidt telescopes may frequently be too small to avoid overlapping spectra; the central regions of both LMC and SMC are rather crowded. The limiting magnitude of the Uppsala survey is for instance about I = 13.7. This means that stars less luminous than about $M_I = -5$ could not be detected even if there were no overlaps to count with. In the SMC the limit must be drawn at $M_I = -5.5$ due to its larger distance. This may be the reason why the attempts to identify red member stars of the SMC with the Uppsala Schmidt telescope failed.

GRISMs

A very efficient method for the detection of faint red stars in the Magellanic Clouds (and in other nearby galaxies) is found in the use of transmission gratings at the prime focus of a large telescope. The method was introduced for blue objects by Hoag and Schroeder (1970: *PASP*, **82**, 1141) and later on refined by Bowen and Vaughan (1973: *PASP*, **85**, 174) who combined the grating with a prism to correct for the effects of aberrations. The GRISM, as it is now called, has been used with good results by Hoag for the detection of faint blue objects, and by Blanco, Blanco and McCarthy (1978: *Nature*, **271**, 638) for identifying carbon stars and M stars in the SMC and the LMC. The latter used the 4 m telescope at CTIO with a field of 0.12 deg^2 and a dispersion of 2300 Å/mm to sample a number of fields in the central regions of the Clouds. Their magnitude limit, on hypersensitized Kodak IV-N plates exposed for 60 min, is about $m_I = 18.5$. This as well as the higher plate scale compensates for the very small field covered by each plate. (At the prime focus of the ESO 3.6 m telescope the scale is 18″.9 per mm; this is to be compared with the 120″ per mm of the Uppsala Schmidt telescope at Mt. Stromlo.) Recently, two GRISMs were constructed by ESO under the direction of Dr. R. Wilson for use with the Gascoigne correctors at the prime focus of the ESO 3.6 m telescope. Their main parameters are:

		Red GRISM	Blue GRISM
Reciprocal linear dispersion		1700	1670 Å/mm
Grating	Gr/mm	150	150
	Blaze	6°17′	3°03′
	First order Littrow λβ	7300 Å	λ 3550 Å
	Blank	BK 7	fused silica
Prism	angle	8°135	4°667
	Blank	BK7	fused silica
Surface layer optimized for		7000 Å	3550 Å
Filter		OG590, 2 mm	BG 24, 2 mm
Field		50 mm ≈16′ diameter except for vignetted part	
Focusing	by multiple exposures with settings near the ones found by knife-edge test without GRISM		

3.6 m GRISM Observations

I had the opportunity to use the red GRISM during 3 nights in the middle of October 1979. The seeing was good to reasonably good during all three nights and a number of rather useful plates were obtained. All plates used were IV-N emulsions, hypersensitized in $AgNO_3$, and efficiently so by E. Bahamondes. The setting of the telescope was done with outmost precision by J. Véliz. This was fundamental as there was no possibility to check the field except by removing the GRISM.

I observed 6 fields in the Small Magellanic Cloud, 3 in the Large Cloud, 2 in the Sculptor dwarf galaxy, 3 in the Fornax dwarf galaxy and 1 in the irregular galaxy NGC 6822. Most exposures were of 50 min duration; this was found to give the most suitable sky background for identification of faint red stars. The limiting magnitude in the I system has not yet been accurately determined. In Fornax and Sculptor we have identified some stars used for calibration in the U, B, V system: stars with V = 18.3 and colours around B–V = 1.1 are well exposed. It appears quite likely that late M stars and C stars of I = 18 may be identified.

The fields in the SMC were chosen between $01^h\,08^m$ and $01^h\,30^m$ along the Wing (~−73°.4), and with one observation at $00^h\,40^m$, −73°.4. The distribution of the identified carbon stars, a total of 39, confirms the results by Blanco et al. that these stars are strongly concentrated towards the centre of the Cloud. We find a larger number of M stars than Blanco et al., but as time has not permitted a detailed classification we have to postpone all comments.

Of the 3 fields observed in the LMC one is at $05^h\,22^m$; −72°02′ i.e. a few degrees below the Bar. The other two are in the outer eastern parts of the LMC, in the region between $6^h\,10^m$ and $6^h\,30^m$ where we had previously found a surprisingly high number of carbon stars.

In the three fields we had previously identified 2 or 3 carbon stars on our Schmidt plates. An appreciable increase on these numbers was to be expected following the results by Blanco et al. This was found true for the crowded region to the south of the Bar where we identified a total of 10 carbon stars (against 2 previously known). In the more peripheral fields we added 2 and 1, respectively, to the 3 already known. This shows the dependence of the completeness of an objective-prism survey on the general background field. It is of interest to note that one of the "new" carbon stars was previously well covered by the overlapping spectra of the stars in the cluster NGC 2249. As its distance to the centre of the cluster is only about 24″ it may be considered a likely member of the cluster. Of interest in this connection is also the fact that the integrated colours of NGC 2249 (B-V = +.43; U-B = +.20) resemble those of NGC 2209 (+.52; +.36), with two carbon stars as likely members, rather much.

Carbon Stars in Dwarf Galaxies

Of the two fields photographed in the Sculptor spheroidal dwarf galaxy (m-M = 19.5) the one of the central region of the galaxy contains 2 carbon stars and 7 M stars; in the field 22′ to the south there are 1 carbon star and 3 M stars.

In the Fornax dwarf galaxy (m-M = 21.4) we have so far identified 69 red stars. The distribution of the carbon stars is sufficiently uneven to indicate that regions of different degrees of metal deficiency exist.

The plate centred on the accepted centre of the dwarf galaxy contains 26 carbon stars and 11 M stars; of the two other fields, which are 16′ to the north and to the south of the centre, respectively, the northern one contains 7 carbon stars and 12 M stars, and the southern one 1 carbon star and 12 M stars. Of the 7 carbon stars in the northern field, 6 fall between globular cluster No. 3 (see e.g. Hodge 1961: *A.J.*, **66**, 83) and the centre, i.e. within 825 pc from the a.

b.

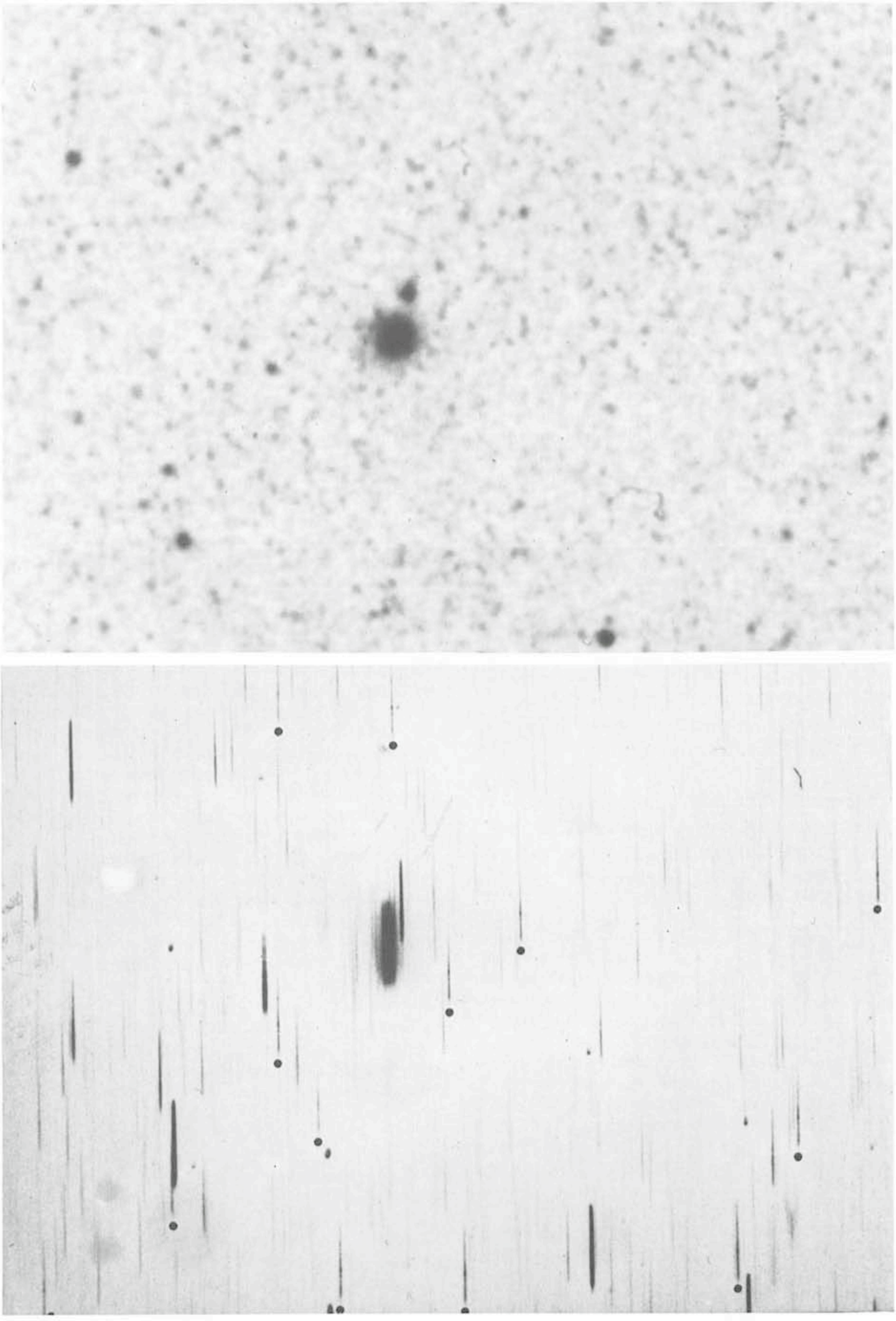

Fig. 1: *The field around the globular cluster No. 4 in the Fornax dwarf galaxy. The scale is 1 arcmin = 22.5 mm. North is up and East is to the left.*

a. *From the ESO(B) Survey. The limiting magnitude is about B = 21.5.*

b. *From a 60-min exposure with the red GRISM at the prime focus of the 3.6 m telescope. Carbon stars are identified by dots at the red ends of their spectra. A number of M stars are easily identified in the field from the pronounced TiO bands.*

centre. At a distance of 188 kpc the galaxy has a radius of 3.3 kpc. In the central field 22 carbon stars are within 330 pc from cluster No. 4, 6 are within 110 pc. All observations so far show that cluster No. 4 is the least metal poor, having [Fe/H] = −1.4. The most metal-poor clusters observed in this galaxy have [Fe/H] = −2.1. It has been suggested, on the basis of the distribution of the Magellanic Clouds, that a certain metal-poorness favours the formation of carbon stars of this type. Obviously, this poorness should not go too far, otherwise the Sculptor galaxy with [Fe/H] ≤ -1.8 should have been far richer in carbon stars than indicated by this survey.

We turn, finally, to the irregular galaxy NGC 6822. Its apparent distance modulus is m–M ~ 25. With a reddening of about E(B-V) = 0.4 its distance is about 616 kpc. From previous investigations it is known to contain many blue and red supergiants. 16 H II regions have been identified, and many similarities to the LMC have been noted. There may be a slight deficiency in N and O.

If the carbon stars have $M_I \sim -4$ we are not likely to reach them in this galaxy. Our survey has given 23 M stars. A number of them are certainly members of the galaxy; some may be foreground objects. This has to be checked, preferably with velocity determination.

For all five galaxies holds that spectroscopy of the identified faint M stars, too, should be rewarding. They have to be either members of these galaxies, or dwarf members of our galaxy. In either case, the knowledge of their characteristics would contribute essentially to the solutions of fundamental problems concerning the evolution of galaxies.

Photometric and Polarimetric Observations in NGC 6334, NGC 6357 and NGC 6302

Th. Neckel

Polarization is observed in the light of many stars and is normally attributed to interstellar dust particles aligned in an interstellar magnetic field. It is, however, quite possible that—at least in some cases—the polarization arises in dusty envelopes, surrounding stars during the earliest phases of their life. Dr. Thorsten Neckel from the Max-Planck-Institut für Astronomie in Heidelberg, FRG, has recently obtained observations of such objects from La Silla. Combining photometric and polarimetric measurements, it has become possible to provide new, important evidence for the intrinsic, bipolar model.

Several investigations carried out at the Max-Planck-Institut für Astronomie in Heidelberg within the last years are concerned with problems of star formation. Star formation is restricted to regions of high dust densities. Observations of embedded sources are often possible only at infrared wavelengths, because of the higher extinction for the visible light. One of our powerful instruments for observing recently-formed stars is an image-tube camera which is used at wavelengths up to 1 micron. Hitherto invisible young stars in the giant H II regions M 17, W 3 and others have been detected.

In these H II regions very high degrees of polarization have been found. Whereas the "normal" interstellar dust produces polarization values up to about 5 %, polarization degrees higher than 20 % were observed in M 17 and W 3 (Schulz et al., 1978). An appreciable part of the high extinction of these stars occurs in the H II regions themselves, where the densities of gas and dust are very high. Under these conditions the "Davis-Greenstein mechanism" for aligning the dust particles becomes very ineffective. So it proved to be difficult to explain these high polarization values by anisotropic extinction due to dust particles aligned in an interstellar magnetic field. Therefore, the observed high degrees of polarization are possibly due to a different mechanism (Elsässer and Staude, 1978).

Dust Envelopes

One possibility is the assumption of non-spherical dust envelopes around stars in which scattering by dust grains or electrons produces the polarization. Bipolar nebulae like "Minkowski's foot print" or S 106 are examples for such a configuration. These objects exhibit around a central star a disk of dust being nearly parallel to the line of sight and, therefore, obscuring the central star. (The central star in S 106 becomes visible in the near infrared, as shown by photographs with our image-tube camera (Eiroa et al. (1979).) Extended lobes of gas and dust, vertical to the dust disk, are visible. In these directions the disk is not optically thick. Therefore the light of the central star can illuminate the lobes. In the lobes we see predominantly scattered light which is highly polarized. The two lobes of "Minkowski's foot print", for example, are polarized to 15 % and 25 % respectively (Cohen and Kuhi, 1977).

Whereas "Minkowski's foot print" and S 106 are not obviously related to regions of star formation, the peculiar bipolar nebula NGC 6302 is only 1°5 distant from NGC 6334, one of the largest H II regions in the Southern Milky Way. In NGC 6334 star formation is still going on, as indicated by the presence of OH masers and other very young objects (see Alloin and Tenorio-Tagle, 1979). Furthermore, the more evolved H II region NGC 6357 is located 1°5 away. The part of the Southern Milky Way containing NGC 6302, 6357 and 6334 is shown in figure 1a. The photograph is from the red print of the Palomar Sky Survey. The H II regions NGC 6334 and 6357 are members of the Sagittarius spiral arm; for NGC 6302 no distance estimation has yet been possible.

The Observations

NGC 6334 and NGC 6357 contain many early-type stars. For the brighter ones, UBV observations were already made in 1976 at the Gamsberg in South West Africa using our 50 cm telescope, from which resulted the distance 1.72 kpc for both H II regions. Additional fainter stars were observed with the ESO 1 m telescope in June 1979. Their (B-V)/(U-B) two-colour diagram is shown in figure 2. 18 stars of spectral type O to B 2 were found in NGC 6357 and 13 in NGC 6357. In NGC 6357 nearly all of them are located within the two compact radio sources G 353.2+0.9 and G 353.1+0.7. These radio sources are delineated in figure 1b by two isophotes of the 1.95 cm continuum radiation observed by Schraml and Mezger (1969). Figure 2 shows that all these stars have similar colour excesses, corresponding to extinction values in the range $A_v = 5^m$ to 6^m. Some foreground stars exhibit extinction values up to $2\overset{m}{.}4$, so that the internal extinction in the H II region itself amounts to about 3^m.

For all early-type stars in NGC 6357, except the faintest ones, polarization measurements were made, also at the ESO 1 m telescope during 3 nights in June 1979. The polarization vectors (after subtracting the foreground polarization) are shown in figure 1b. Whereas inside the two compact radio sources all polarization vectors are nearly parallel, their mean directions, 146° and 79° respectively, are very different. In G 353.2+0.9 the polarization is surprisingly small. This may indicate that within this region the magnetic field is nearly parallel to the line of sight or that the mechanism of aligning the dust grains is not efficient.

The extinction values in NGC 6334 are generally smaller, ranging from 3^m to $4\overset{m}{.}6$, only two stars with appreciably higher A_v values, about $6\overset{m}{.}50$, have been found. Star no. 34,

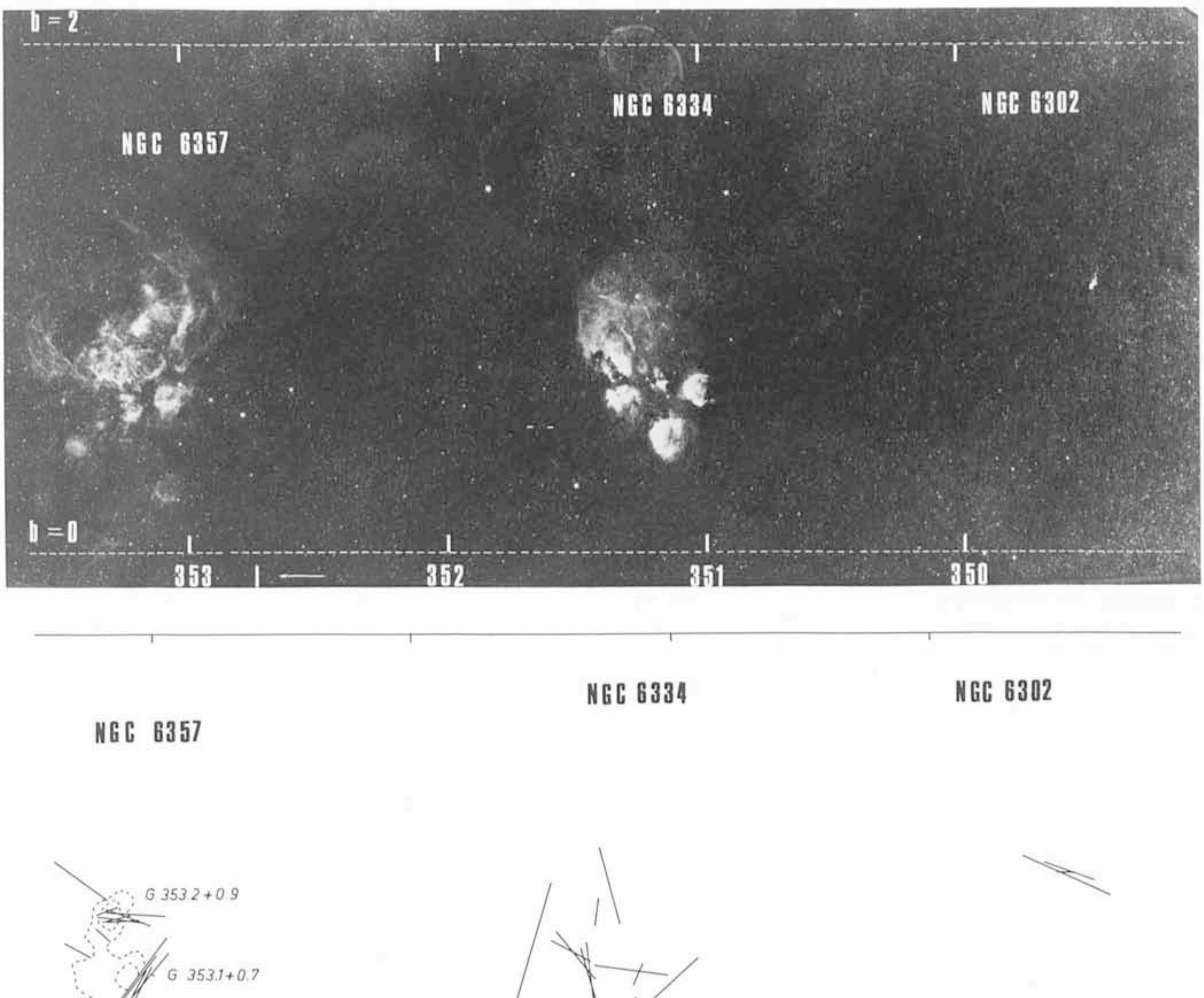

Fig. 1a: *The Milky Way in Scorpius with the H II regions NGC 6334 and NGC 6357 and the peculiar bipolar nebula NGC 6302.*
Fig. 1b: *The polarization vectors for the observed stars in the H II regions NGC 6334 and NGC 6357 and in the lobes and the centre of NGC 6302. In NGC 6357 two isophotes of the 1.95 cm radiation are shown.*

marked in figure 1, is situated in a dark cloud which seems to be associated with NGC 6334. It has the highest observed polarization, (p_v = 10.70 % ± 0.60 % and 11.5 % after subtracting the foreground polarization) which exceeds those of the other stars observed in NGC 6334 by a factor 3 to 4. However, its extinction is only about 2^m higher. This indicates that in the dark cloud the conditions for polarizing the star light are very different from those in the H II region. A similar behaviour was found in M 17, where all extremely high polarization values are observed in the dark cloud associated with M 17 (Lenzen and Schulz, 1979). A hint about an unusual mechanism for this high polarization may be expected from its wavelength dependence. Because star 34 was observed for the first time during the last of my 3 polarimetric nights, only 1 measurement in U, B, and V respectively could be made. Usually the polarization has its maximum at about 5500 Å. For star 34, however, the highest value was found in the ultraviolet, p_u = 13.0 % ± 3.6 %. Because of the faintness of star 34, U = $15^m.5$, the wavelength dependence of p for this star still needs further observations.

NGC 6302

NGC 6302 is very peculiar in many respects. Although listed in the catalogue of planetary nebulae by Perek and Kohoutek, it is clearly not a typical planetary nebula, as pointed out already by Minkowski and Johnson (1967). Short-exposure photographs of this bipolar nebula show a dark lane between the two lobes (see Minkowski and Johnson, 1967). An excellent photograph of NGC 6302 is published in the ESO *Messenger* 15, p. 11. NGC 6302 is one of the most highly excited gaseous nebulae known. From the relative halfwidths of the [N II] and H α profiles, Elliott and Meaburn (1977) found in the centre of NGC 6302 the extremely high electron temperature T_e = 26,700 K. T_e values > 20,000 K are unlikely even when radiatively excited by a star with a surface temperature of 10^5 K. Therefore, the high T_e value in NGC 6302 indicates collisional excitation. As the possible source of energy a star has been suggested, which emits an energetic stellar wind. However, no central object has been found up to now. During my 3 polarimetric nights in June 1979 I have measured the polarization at 3 points in NGC 6302: in its centre as well as in the brightest parts of the lobes using a 16" diaphragm. In the centre the polarization is found to be below 1 %. In the lobes however, much higher values have been found, up to 5 %, and the directions of p are nearly vertical to the directions to the centre. Therefore the light of NGC 6302 must be partly scattered light from the central source, surrounded by dust, which is optically thick in the line of sight but not in the directions to the lobes. The simplest model is a dust disk seen edge-on similar to those in "Minkowski's foot print" or S106.

NGC 6302 is surrounded by many extremely red stars. The dust, which is responsible for their high reddening, appears to be quite distant, because also many unreddened stars in the same region are present. If NGC 6302 is physically related to this dust cloud, it also cannot be nearby. So it seems probable that the nearness of NGC 6302 to the H II regions NGC 6334 and NGC 6357 is not a projection effect, but they are in reality "neighbour" objects in the Sagittarius spiral arm.

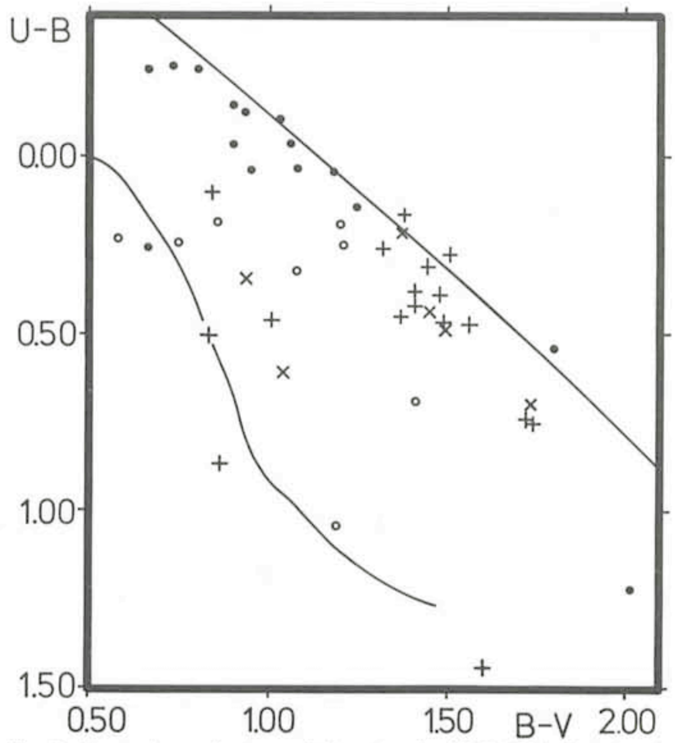

Fig. 2: *Two-colour diagram of the stars in NGC 6334 (dots) and NGC 6357 (upright crosses for stars in G353.2+0.9, diagonal crosses for stars in G353.1+0.7 and open circles for stars outside the compact radio sources). The two lines are the reddening line for an O5 star and the unreddened main sequence.*

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Tentative Time-table of Council Sessions and Committee Meetings in 1980

The following dates and locations have been reserved for meetings of the ESO Council and Committees:

January 21–22	Finance Committee, Geneva
(February 6	Council, Geneva)
(April 17–18	Finance Committee, Geneva)
May 20	Users Committee
May 21	Scientific/Technical Committee, Geneva
May 22	Committee of Council, Geneva
June 2–4	Observing Programmes Committee, Geneva
June 18–19	Finance Committee, Brussels
June 20	Council, Brussels
November 4	Scientific/Technical Committee, Munich
November 5–6	Finance Committee, Munich
November 7	Committee of Council, Munich
November 27–28	Council, Munich
December 2–4	Observing Programmes Committee, Munich

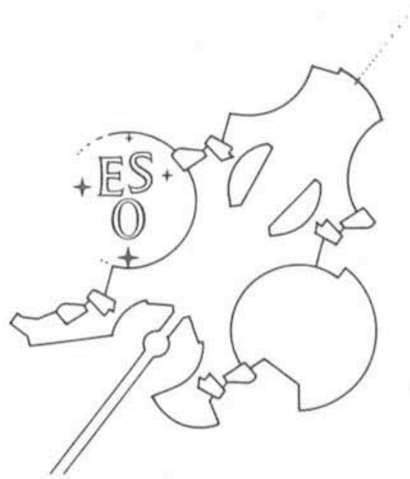
A Roof Over ESO Heads

On November 8th, 1979, another milestone in ESO history was passed. The new building for the future Headquarters in Garching, just north of Munich, was the scene of a happy celebration, on the occasion of the "setting up the roof", or "Richtfest" as it is called in Bavaria.

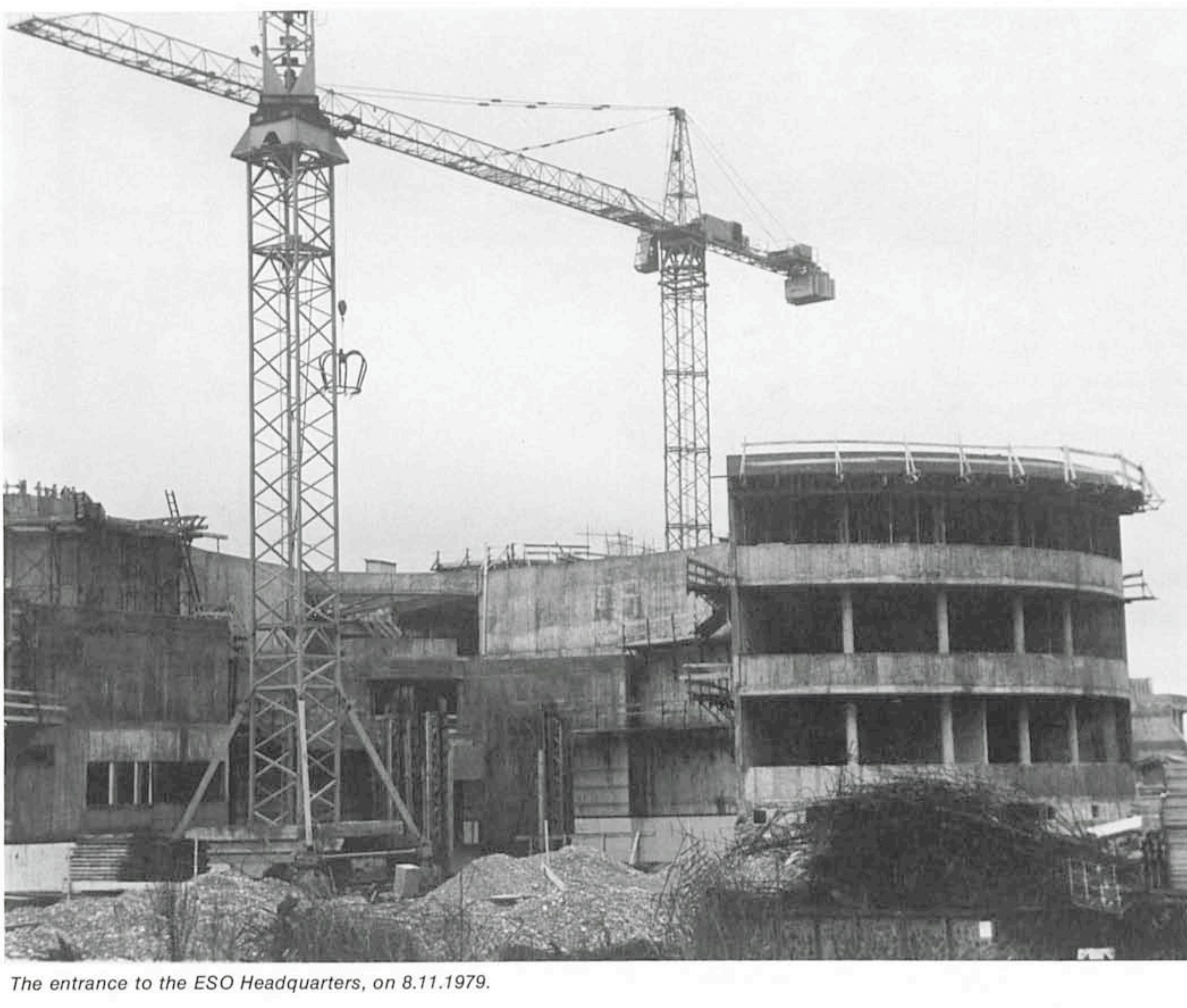
Most of the people who participated in the planning and construction were present, from the architects, the engineers and the construction workers to some ESO staff, headed by the Director General. A series of elegant speeches marked the occasion; the Max-Planck Institute that directs the construction was represented by the "Baudirektor", P. Löwenhauser; W. A. Nöbel spoke on behalf of the architectural firm, Fehling & Gogel; Professor L. Woltjer thanked on behalf of ESO and finally the "Richtspruch" was effectively declaimed by H. Kühne, Zimmerpolier.

The building is presently being terminated on the outside and the last concrete will soon be in place. The installation of the inside equipment has started and it was felt that everything will be ready to receive the ESO staff by late summer 1980.

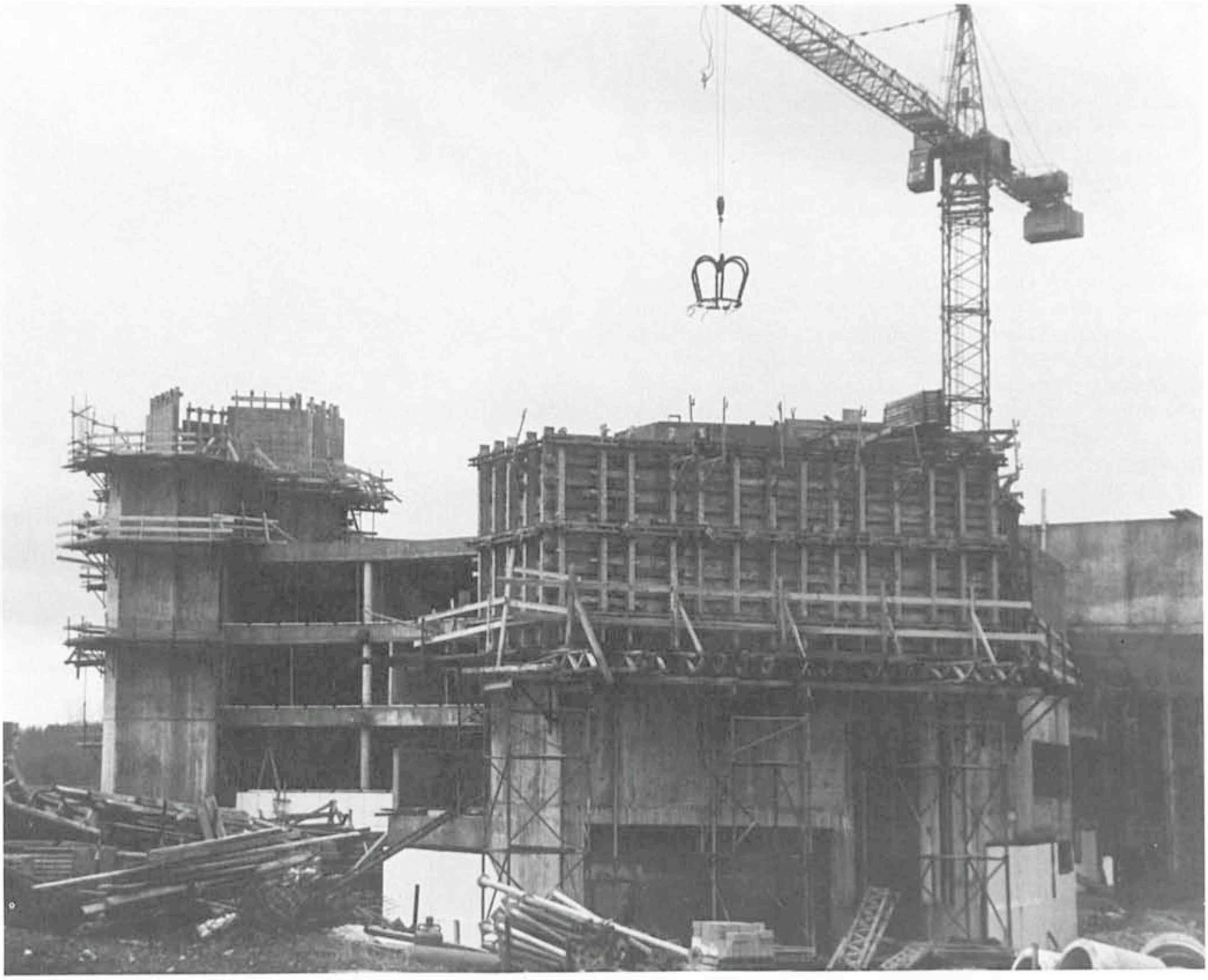
Some of these were privileged to make a thorough inspection of their new "professional home" during the morning of November 9. It was a great moment to see for the first time the actual building, rather than the drawings and architects' models and to walk around in the vast space. Great pains were taken to make the building functional in the sense that related services are close to each other. Nevertheless, the architects have also produced an



...hat Richtfest
...has setting up its roof



The entrance to the ESO Headquarters, on 8.11.1979.



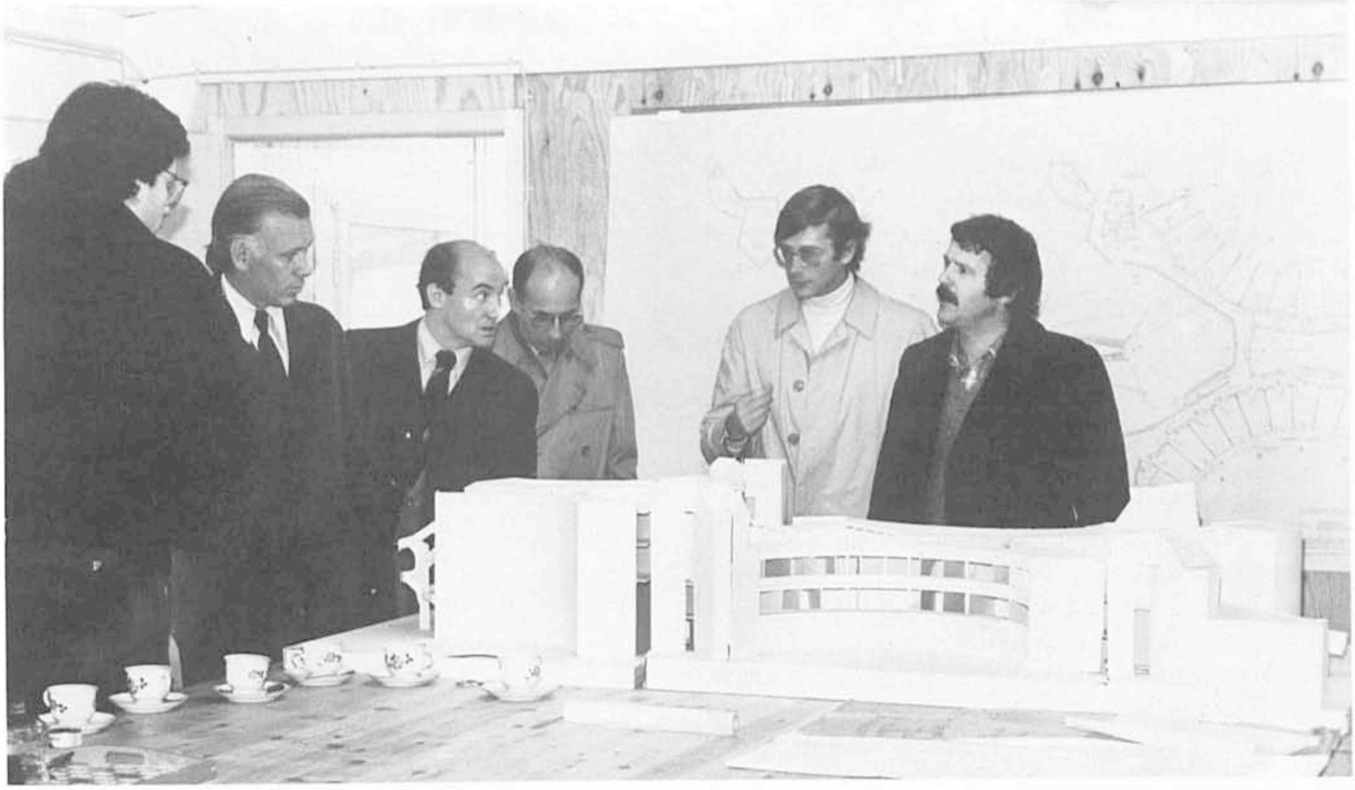
The north area that will later house the ESO Administration and part of the Scientific Group.

impressive and artistically very interesting complex. The last speaker expressed the views of many in his humourous way when he spoke of the "runde, rechteckige, ovale, gekrümmte, vieleckige, versprungene, achteckige, verschobene, 22.5-gradige, trapezförmige und manchmal auch gerade Bauwerk"!

The building was inspected by the ESO Council in late November, on the occasion of the Council meeting in Munich.

Some photographic impressions may be seen on these pages.

At the entrance to the construction site. ▶



ESO staff members in the architect's office, during the morning of 9.11.1979.

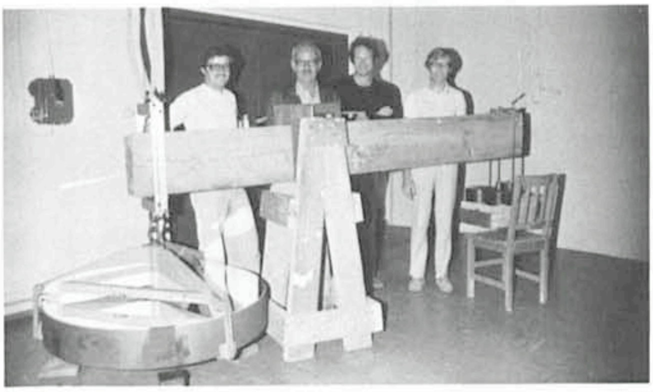
NEWS and NOTES

Heavyweight Technology on La Silla

In our article on recent improvements in the optical quality of the La Silla telescopes in the *Messenger* No. 16, we mentioned the wonderful balance constructed by our colleague Jan van der Ven. This had been used to weigh the optical elements of the Schmidt telescope and was pressed into service again for weighing the primary of the 1 m photometric telescope, an operation necessary for optimizing the support system in view of doubts about the mirror's theoretical weight.

Jan has found a photograph showing this remarkable weighing operation and we print it here to prove that the La Silla technology is, indeed, very solidly based:

From left to right in the picture: The 1 m mirror freshly washed; Paul Giordano (Optics group, La Silla); Jan van der Ven (Mechanics group, La Silla); Ray Wilson and Francis Franza (Optics group, Geneva).



The result: weight of the 1 m primary = 346.1 kg ± 2 kg. The theoretical value was 344.6 kg—remarkably good agreement.

Further investigation of the effects of the secondary mount of the 1 m telescope is under way as well as a complete analysis and optical overhaul of the 1.5 m spectroscopic telescope. This work will be reported in a future issue of the *Messenger*.

Ray Wilson

ESO Workshop on Two-dimensional Photometry

An ESO Workshop on Two-dimensional Photometry was held in Noordwijkerhout, the Netherlands, on 22–24 November 1979 in collaboration with Sterrewacht Leiden. Approximately 90 astronomers attended the $2^1/_2$ days of meetings. A total of 39 papers were read including 9 invited reviews. The first few talks covered the optical instruments available for acquiring the desired data and for putting them in a digital format for subsequent analysis. One session was devoted to the techniques of data analysis and the kinds of computers and displays which seem desirable for aiding analysis. The final sessions dealt more explicitly with the scientific programmes which could be or are being pursued. One afternoon was reserved for an excursion to the Leiden Observatory facilities including the "Astroscan" and the "Comtal" display.

It was obvious that this was a timely meeting. Some astronomers are already making good use of the new facilities and techniques which are available, and many astronomers are anxious to do the same. The "summer camp" atmosphere of the conference centre allowed for a great deal of informal exchanges in addition to the formal programme.

The proceedings of this workshop will be published by ESO and should be available by March 1980. Copies of the proceedings can be obtained by writing to the Scientific Group Secretary, Mrs. R. van Doesburg at ESO, c/o CERN, CH-1211 Geneva 23, Switzerland.

P. Crane

The Prediction of On Site Telescope Performance

D. S. Brown

The acceptance tests of an optical mirror are most often based on measurements of the slopes on its surface and the geometrical concentration of light. However, the result depends rather critically on the way of sampling and, furthermore, the final quality of the telescope is a combination (convolution) of many parameters: the optical quality, seeing, guiding, etc.

Dr. D.S. Brown is responsible for the manufacturing and testing at Grubb Parson's workshop in Newcastle upon Tyne, which has recently polished the 1.5 m mirror for the new Danish telescope on La Silla and the optics for the 3.6 m CAT. Having spent most of his working life in the manufacture of astronomical optics, he has a keen interest in the prediction of actual telescope performance, based on tests in the optical shop. He explains —with a clear direction towards observing astronomers—that better test methods are now available which will let the future user know with good confidence how good (or bad) his new telescope will be, long before the first real observations are made.

In a recent *Messenger* article (No. 17, p. 14) describing the optical performance of the Danish 1.5 m telescope at La Silla, Drs. Andersen and Niss refer to the scepticism with which seasoned observers respond to predictions of image quality based on works tests. This response is historically well justified since there are many accounts of works tests on mirrors indicating levels of performance not achieved by the telescope when operational. They give some reasons why operational performance falls short of that achieved during works tests (flexure, misalignment, seeing, guiding errors) but do not explore the reasons why the effects of these are not allowed for when predictions are made.

In the past, several factors have made reliable prediction difficult, but recent advances in knowledge and technology make it possible to overcome these difficulties. One major problem has been the lack of reliable quantitative descriptions of the image deterioration due to seeing, a second has been the widespread use of geometrical formulae in converting test data (usually in the form of wavefront slopes) into an intensity distribution in the star image. A third, less well known difficulty is the occurrence of systematic errors in some tests. Several test methods (i.e. Hartmann, Gaviola, shearing interferometer) determine the mean wavefront slopes over finite areas of wavefront. These mean slopes can be significantly less than the "true" slopes at the centres of the averaging areas. Finally the astronomer usually prefers to define optical quality in terms of image size, which appears convenient and direct. Unfortunately it is then necessary to combine the effects of the various sources of degradation by convolution

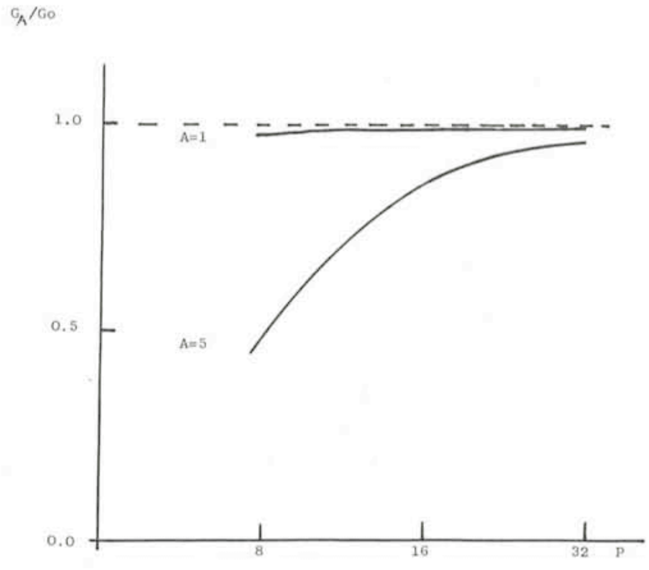


Fig 1. Loss of sensitivity for test methods averaging information over width A in the aperture, for periodic errors of period P.

and for many astronomers and opticians this is an unfamiliar, time-consuming and often inaccurate process.

Some idea of the scale of the problems can be obtained by considering one-dimensional sinusoidal errors of differing period (P). Simple expression can be deduced for the relationship between the "true" and averaged geometrical slopes, for the diffracted image spread and for the Strehl Intensity. Figure 1 shows the relationship between "true" geometrical image width (Go) and the measured width (G_A) obtained by averaging over an area of width A, for values A = 1 and A = 5. For A = 1 the loss of sensitivity is small but for A = 5 it is relatively large. In many Hartmann or shearing interferometer tests, values of A between 2 and 7 cm would be used and in the upper part of this range significant loss of sensitivity would be expected for errors with periods less than 20 cm. Figure 2 shows the relationship

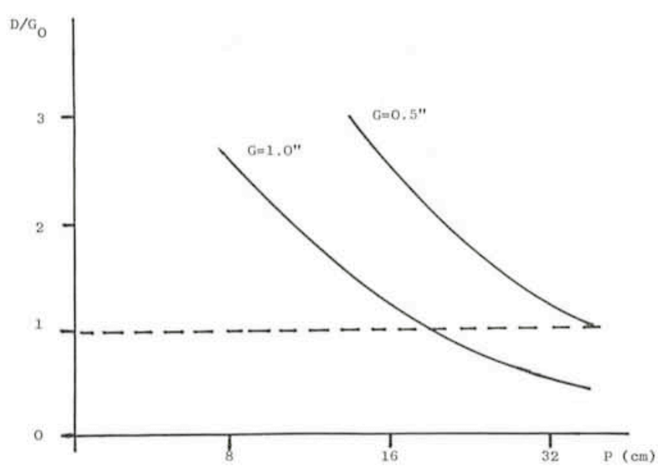


Fig 2. Ratio of diffracted to geometrical image widths as function of period.

between the diffracted image width D (separation of first-order maxima) and Go for errors with Go = 0.5 and 1.0 arc-second. Since D is independent of the amplitude of the wavefront error, but dependent on period, the curves show strong dependence on both Go and period.

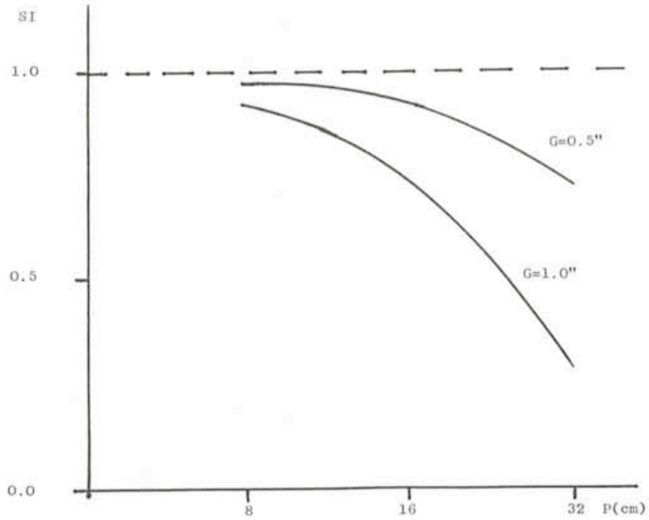


Fig 3. Strehl intensity for periodic errors of geometrical spread 0.5 & 1 arc second.

The Strehl intensity (ratio of the intensity in the central maximum to that for an aberration-free wavefront) is shown in figure 3 for errors with Go = 0.5 and 1.0 arc-second. For short periods the first-order maxima lie outside the geometrical image, but for the periods where D/Go<1, the two first-order images lie within the geometrical image. Figure 4 shows the fractional energy (E) within the geometrical image width Go for Go = 0.5 and 1.0 arc-second.

To obtain an accurate prediction of performance it is necessary to combine the effects of aperture diffraction, seeing and telescope aberrations using diffraction-based calculation. A possible approach is to calculate the point

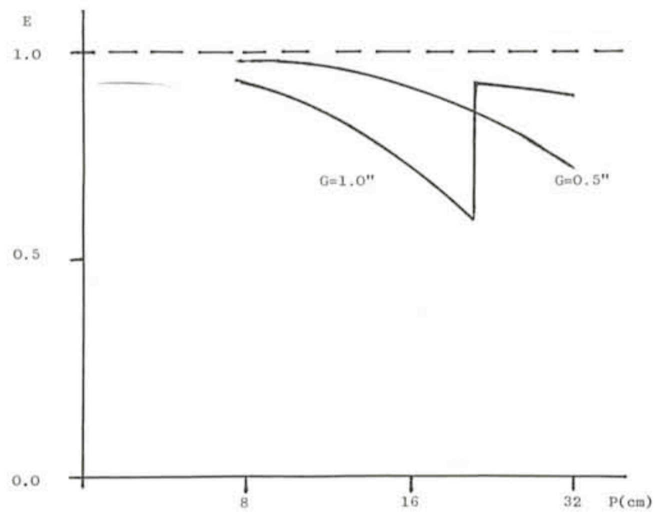


Fig 4. Encircled energy for periodic errors of geometrical image width 0.5 and 1.0 arc second. The discontinuity at P=20 in the curve for G=1.0 is due to the movement of first order diffracted images into the geometrical width when P exceeds this critical value.

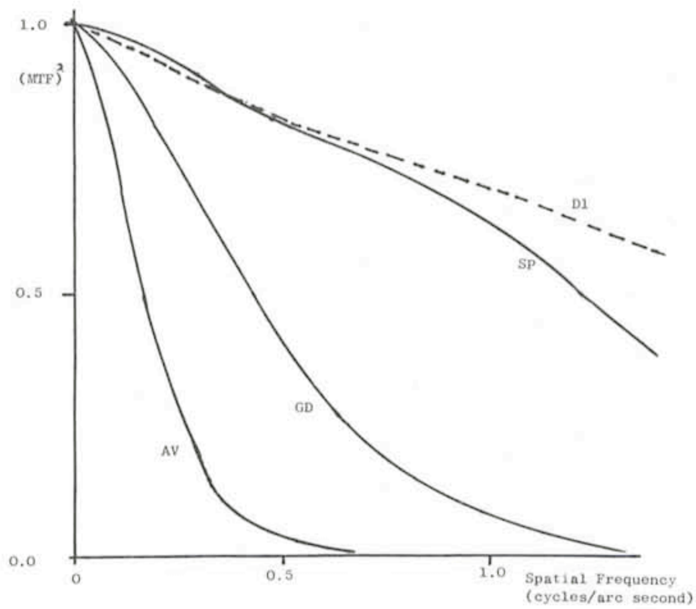


Fig 5. Squared MFT data for average seeing (AV), good seeing (GD), a typical specification (SP), and diffraction by an aperture of 1 metre diameter (D1).

spread function (PSF) for the telescope and convolute this with the atmospheric PSF. An alternative is to make the calculations in the spatial frequency domain, describing all the contributions in terms of modulation transfer function (MTF). The second method is much easier to carry out and is well established in other optical applications, but produces a result which astronomers do not easily relate to the point imaging characteristics of the system. It is not difficult to transform the MTF for the system into a PSF but this is often unnecessary since the intensity at the centre of the image can be obtained very simply from the MTF data.

The value of central intensity for the image of a point source is approximately equal to the integrated value of $(MTF)^2$. Central intensities so obtained can only be relative values and a useful basis for comparison is the central intensity for atmospheric seeing alone. Since the image degradation produced by the telescope will usually be significantly less than that produced by the atmosphere, the

Fig 6. Ratio of central intensities of image after and before degradation by telescopes for average and good seeing. Dashed curves are for aberration free telescopes, full curves for telescopes just meeting the typical specification.

increase in image diameter will be small. The change in central intensity is relatively larger and provides a sensitive and conceptually useful indicator of image quality.

Calculations of telescope-induced degradation of image quality are easily carried out if the MTF is available. It is interesting to note that the effects of aperture diffraction alone can be calculated in this way once the atmospheric MTF is determined. Figure 5 shows curves of $(MTF)^2$ for average and good seeing, diffraction by a 1 metre aperture and for the aberrations of a telescope mirror just meeting a typical modern specification. Figure 6 shows the relationship between R (the ratio of central intensities after and before degradation by the telescope) and telescope aperture, for average and good seeing. The curves are plotted for diffraction only and for telescopes with aberration corresponding to the typical specification. From figure 6 it is clear that at small apertures and in average seeing, aberrations are responsible for only a minor part of the telescope-induced image degradation. For larger apertures and good seeing the telescope aberrations are more important and it could be argued that the specification used is appropriate for small apertures but is not sufficiently stringent for larger telescopes.

The principal advantage of the use of MTF is the simplicity of the calculations needed for reliable derivation of the image quality of a complete system, which can include the atmosphere, telescope aperture and aberrations. Measurement of MTF for large mirrors does not appear to present any major difficulty since any test method capable of producing reliable wavefront-height data can give the MTF. To produce data of high accuracy in the spatial frequencies of greatest interest (those where the atmospheric MTF is appreciably greater than zero), some revision of test details may be needed. Calculation of central intensity via MTF provides a simple method of expressing image quality, and the ratio of the central intensities of the system (atmosphere + telescope) to that of the atmosphere alone, provides a numerical measure of optical performance that is practical, easily visualized and appropriate to the conditions of use.

Neutron Stars

E. J. Zuiderwijk

It is a common trick among astronomers who give popular lectures to shock the audience with large numbers. The statement that a matchbox of material from a white dwarf weighs as much as several large locomotives (or elephants if there are influential ecologists present) is always of great effect. But that is all antique by modern comparison. Now, one cubic millimetre of a neutron star (about the size of the head of a pin) weighs one million tons! Dr. Ed Zuiderwijk of the ESO Scientific Group in Geneva is engaged in a theoretical and observational study of these incredible objects. There is still much to be learned from them, both for physicists who look for the ultimate properties of matter and for astronomers who wonder how stars end their life.

Neutron stars are among the more exotic objects in the sky. Their mass is comparable to that of our sun, but their diameter is as small as 15 kilometres. The matter in these stars is therefore extremely dense—the density is of the order of 10^{18} kg m^{-3}—and is mainly composed of degenerate neutrons, thus making the star look like a giant atomic nucleus.

The prediction that neutron stars should exist was made by the famous physicist Landau in 1933, immediately following the discovery of the neutron as a constituent of the atomic nucleus. It took, however, more than 30 years before they were discovered. Direct evidence for their existence was found in 1967 when the first radio pulsar was detected. This kind of objects turned out to be rapidly rotating neutron stars. The widely-accepted idea is that they originate from supernova explosions where in a final collapse of the stellar core the exploding star comes to the end of its evolution. With only one (or possibly two) exceptions all neutron stars, appearing to us as radio pulsars, are found to be single, isolated objects. An accurate, direct mass determination for many of these compact stars is therefore not possible.

The discovery of X-ray binaries with the UHURU satellite in 1970 revealed, however, that neutron stars also occur in binary systems. In such a system the neutron star is orbiting a "normal" star, the latter being often detectable from ground-based observatories. The X-rays are produced when kinetic energy of infalling gas is converted into heat at the surface of the neutron star. This matter originates from the "normal" optical star; the mass transfer occurs either because this star overflows its Roche lobe or loses mass by means of a stellar wind. The gravitational potential at the surface of the neutron star is very large (as the stellar radius is very small) and causes the gas to arrive with a velocity of up to one half of the velocity of light ($=3.0 \times 10^8$ m sec^{-1}). Subsequently the gas is heated to a temperature of about 10^7K, which is high enough for the gas to radiate strongly in the X-ray region of the spectrum.

Mass Limit

Theoretical models predict the existence of an upper limit to the mass of a neutron star, above which no stable configuration can exist. A compact object more massive than this upper limit is expected to collapse completely, presumably to become a black hole. The numerical value of this mass limit can be computed from a neutron-star model; the result depends, however, on which particular model is used. To be more specific, the choice of the so-called "equation of state", which describes the relation between the physical quantities pressure, temperature and density of the degenerate nuclear material, is of crucial importance. For such extreme conditions as prevailing inside a neutron star, the equation of state cannot be measured in present-day laboratory experiments and has to be inferred from theoretical nuclear physics. Scientists, however, do not agree which equation of state has to be chosen. Therefore, the predicted numerical values for the limiting mass as computed from several realistic neutron-star models range from 1.4 to about 2.7 solar masses.

Which specific model is the correct one? This question is not likely to be solved in the near future either by improvements of the theory or by more laboratory experiments. Therefore, one way to extend our knowledge about neutron stars—and about matter at nuclear density in general—is to measure directly the masses of these compact objects. Until now only the neutron stars in X-ray binaries offer the opportunity to do so.

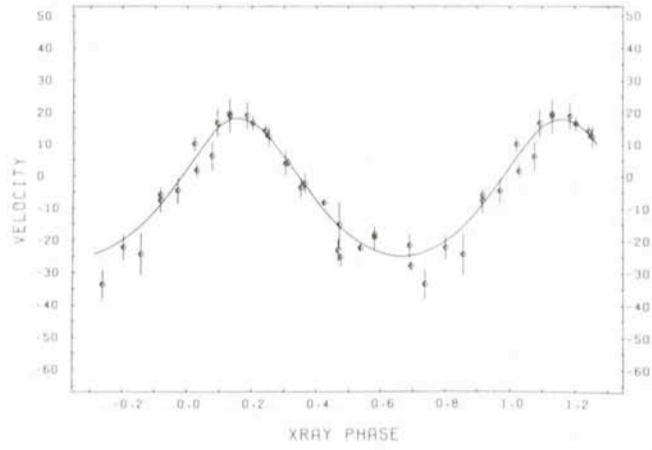


Fig. 1: *Radial velocity variations of HD 77581 as a function of binary phase. Phase zero corresponds to mid X-ray eclipse time. The continuously drawn curve represents the best-fit solution to the data.*

Mass Determination of X-ray Binaries

The masses of the two components in a binary system can be computed if we know the absolute dimensions of both orbits in which the stars revolve around their common centre of mass.

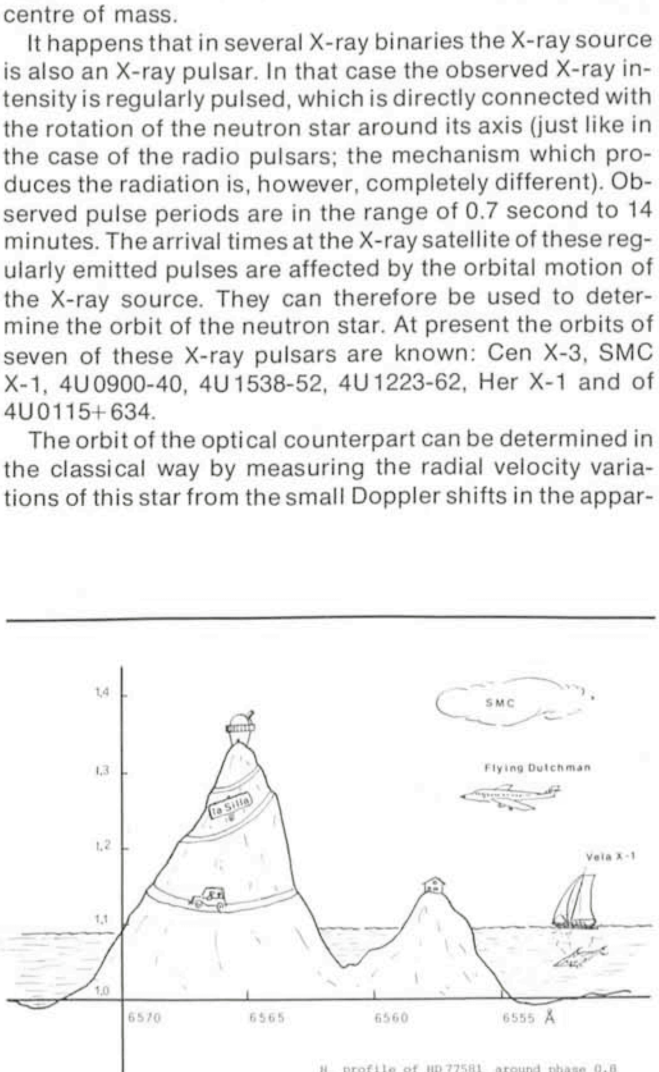
It happens that in several X-ray binaries the X-ray source is also an X-ray pulsar. In that case the observed X-ray intensity is regularly pulsed, which is directly connected with the rotation of the neutron star around its axis (just like in the case of the radio pulsars; the mechanism which produces the radiation is, however, completely different). Observed pulse periods are in the range of 0.7 second to 14 minutes. The arrival times at the X-ray satellite of these regularly emitted pulses are affected by the orbital motion of the X-ray source. They can therefore be used to determine the orbit of the neutron star. At present the orbits of seven of these X-ray pulsars are known: Cen X-3, SMC X-1, 4U0900-40, 4U1538-52, 4U1223-62, Her X-1 and of 4U0115+634.

The orbit of the optical counterpart can be determined in the classical way by measuring the radial velocity variations of this star from the small Doppler shifts in the apparent wavelength of well-chosen absorption lines in its spectrum. This, however, turns out to be a challenging problem. The optical counterparts are generally faint: only two of the well-established X-ray binaries are brighter than 7th magnitude (HD153919/1700-37 and HD77581/0900-40) whereas the counterparts of Cen X-3, SMC X-1, 4U1223-62 and Cyg X-1 are of 9th to 14th magnitude. In order to obtain a reliable estimate of their orbits, one needs high-dispersion spectrograms in the range of 10 Å/mm to 40 Å/mm and this requires a lot of observing time for the fainter stars. Furthermore, the optical spectra of some X-ray binaries are contaminated by strong emission features, distorting the shape of the absorption lines. An accurate velocity measurement is then very difficult, if not impossible. This is for instance the case with the spectra of Be stars such as X-Per (0352+309) and HD102567 (1145-62) or of the Of star HD153919 (1700-37). Fortunately, among the optical counterparts there are several early-type supergiants for which a sufficiently accurate velocity determination can be made.

The X-ray binary HD77581/0900-40 is illustrative for the number of spectrograms needed to obtain a satisfactory accuracy of the determined mass. The orbit of the B0.5Ib supergiant HD77581 was determined by Dr. Jan van Paradijs and his colleagues from the University of Amsterdam (1977, *A&A Suppl.* **30,** 195). They used 92 coudé spectrograms obtained with the ESO 1.5 metre telescope on La Silla to measure the velocity variations of this star. The results are shown in figure 1. The orbit of the X-ray source 0900-40 had been established from SAS-3 observations by Rappaport et al. (1976, *Ap. J.,* L. **206,** L103). Combining these two results one arrives at the following relation between the mass of the neutron star M_n and the inclination of the orbital plane i:

$$M_n \sin^3 i = 1.67 \pm 0.12 \text{ solar masses}$$

Radial velocity measurements refer only to the motion of the two components with respect to the observer along the line of sight. They tell us, however, nothing about the inclination, the angle between the line of sight and the orbital plane. Therefore, as a final step to arrive at the mass of the neutron star we have to estimate this inclination angle i independently. It turns out to be possible to do so through the analysis of photometric variations of the optical counterpart (the "lightcurve"), sometimes in combination with knowledge of the X-ray eclipse duration.



Always in the frontline, THE MESSENGER brings, for the first time—and in stiff competition with other journals—an example of the newest direction in contemporary art. Entitled "Per aspera ad astra", this drawing by J. M. M. van Lith of the modern Dutch school reconfirms the impact of applied astronomy upon other disciplines. From the PhD thesis of Dr. Zuiderwijk.

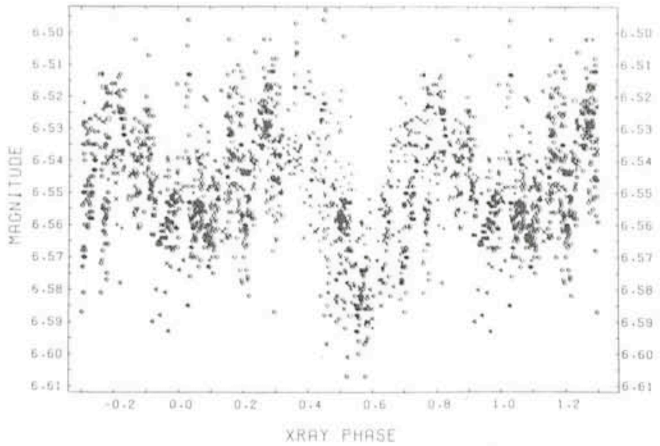


Fig. 2: *Ellipsoidal brightness variations of HD 153919. This V-light curve is composed of approximately one thousand photoelectric measurements obtained by several observers (see also* Messenger *No. 14, p. 8). Clearly visible are the maxima around phase 0.25 and phase 0.75 and the minima near phase 0.0 and phase 0.5.*

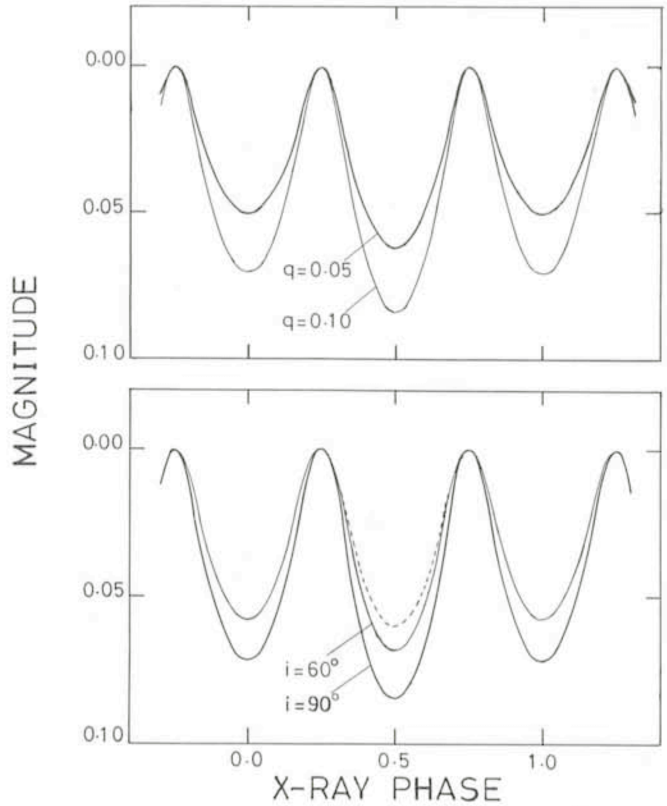


Fig. 4: *Theoretical lightcurves in the Strömgren y passband arising from a tidally and rotationally distorted star of 20 solar masses. The computed magnitude of the star is arbitrarily set to zero at X-ray phase zero.*

Upper part: *The aspect of the lightcurve as a function of the mass ratio q. Both curves are calculated for an inclination angle i=90° while it is assumed that the star fills its Roche lobe completely. A mass ratio q=0.05 corresponds to a neutron-star companion of 1.0 solar mass; a mass ratio q=0.1 to one of 2.0 solar masses. Clearly visible is the increase of the amplitude with increasing value of q.*

Lower part: *These lightcurves are all computed for a mass ratio q=0.1. The continuously drawn curves correspond to a Roche lobe filling star observed with different inclination angles (q0 and 60 degrees). The dashed curve arises from a star which is underfilling its Roche lobe by 5 per cent in radius. This curve coincides around phase zero with the one computed for i=60° and a roche lobe filling star. Notice, however, that the minima in this case are of almost equal brightness.*

Ellipsoidal Variations and Lightcurve Analysis

The lightcurve of the optical companion in an X-ray binary is usually of the so-called ellipsoidal type. It shows in one orbital cycle two maxima of approximately equal brightness and two minima of different depths (figure 2). This is explained by the fact that the star is not a perfect sphere. Tidal forces and rotation produce a slightly elongated shape; in addition, this distortion causes the stellar surface not to be of uniform temperature. The changing aspect—due to binary revolution—results in a modulation of the observed light of the star. Obviously, the more the star is distorted, the larger the amplitude of the variations will be. The most extreme case occurs when the star completely fills its critical Roche lobe.

It is possible to calculate ellipsoidal lightcurves by means of a computer model based on the above given physical "picture". This type of numerical computation is generally carried out as follows. The stellar surface is divided into discrete surface elements, distributed approximately uniformly (figure 3). Each grid element has its own

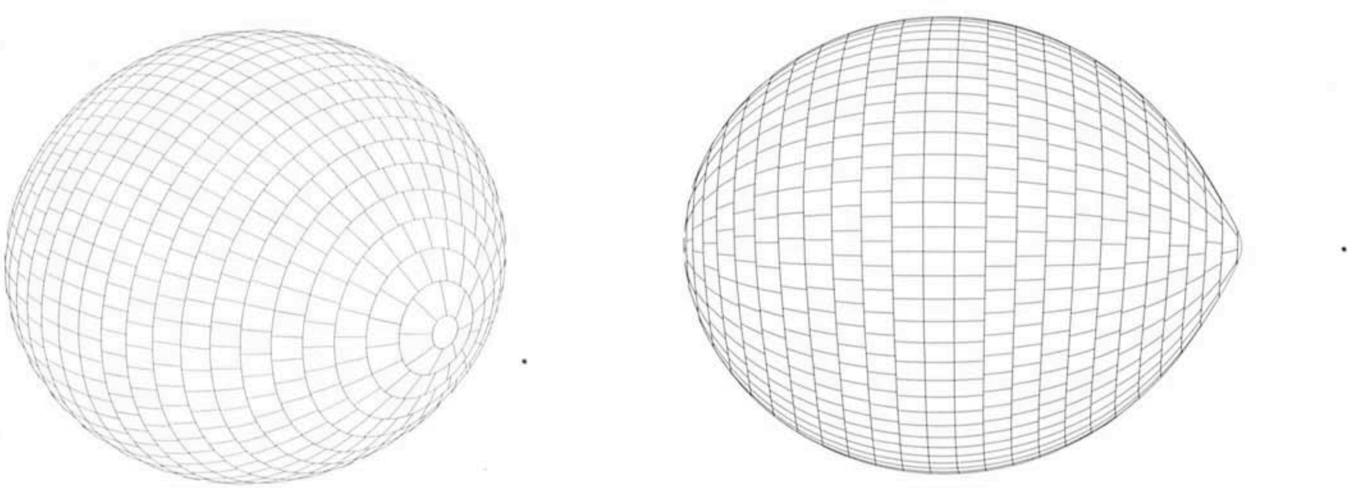


Fig. 3: *The grid of discrete surface elements, as seen from two different directions. A mass ratio q=0.076 was adopted. The optical star fills its Roche lobe almost completely. Notice the elongated shape of the star. The small dot to the right indicates the position of the neutron star.*

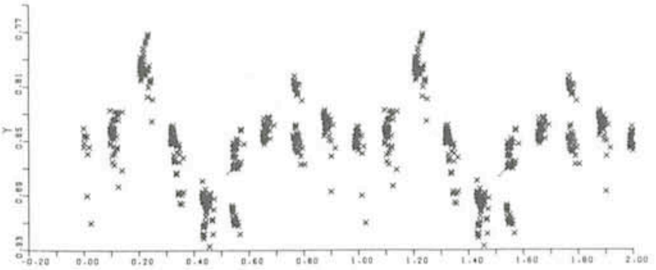


Fig. 5: *The lightcurve of HD 77581 in the Strömgren y passband.*

coordinates, temperature and acceleration of gravity. The radiation emitted towards an observer—situated at a very large distance—is computed by simply adding the contributions from all visible surface elements. A lightcurve is obtained by repeating this final step for different positions of the star in its orbit, with respect to the observer.

In the lightcurve synthesis programme that was developed by the author the local contributions to the total flux are computed using realistic model atmospheres. This programme generates lightcurves for the Strömgren uvby and for the Walraven VBLUW photometric passbands (figure 4). Computations show that the shape of the lightcurve, and in particular the amplitude of the variations, are mainly determined by (1) the ratio q of the mass of the neutron star to that of the optical component (rather than the masses themselves), (2) the ratio r of the mean radius of the star to the binary separation, and (3) the inclination angle i. The parameters q and r determine how much the star is distorted.

In order to find their numerical values in the case of a real-life X-ray binary, we vary these three parameters until an optimal agreement is obtained between the calculated and observed lightcurve of the star.

The value of q is already available for HD77581/0900-40 from the radial velocity and X-ray pulse measurements ($q = 0.076$). Using the amplitude of the lightcurve of this system (figure 5) we were able to derive a reliable constraint for the inclination angle: the value of i is between 75 and 90 degrees, i.e. less than 15 degrees from the line of sight. Therefore, the most probable value for the mass of the neutron star in this system is 1.74 solar masses. It was also found that the supergiant HD77581 almost completely fills its critical lobe.

We would like to apply a similar analysis to the lightcurves of other X-ray binaries, including those systems where q is not very well known. It will be clear that we need very accurate observed lightcurves in order to obtain reliable constraints on the system parameters. From figure 1 it can be seen that many observations are needed to determine an average lightcurve, because of the considerable intrinsic scatter. Therefore, a long-term observing programme is in progress on La Silla to obtain accurate multicolour lightcurves of Galactic and Magellanic-Cloud sources. These observations are made by astronomers from ESO and from the University of Amsterdam with the Dutch 90 cm telescope and Walraven photometer.

Image Processing at the Astronomical Institute of the Ruhr-Universität Bochum

T. Kreidl, M. Buchholz, Ch. Winkler

Image processing of astronomical photographs or, in general, one- and two-dimensional data, play a larger and larger role in the reduction of observations. Several institutes in Europe are acquiring their own hardware and, more recently, an effort to exchange the associated programmes, the software, has been initiated. At the Astronomical Institute of the Ruhr University in Bochum, image processing is already well developed, as explain Drs. T. Kreidl and M. Buchholz together with graduate student Ch. Winkler in this review of the Bochum system.

The Need for Image Processing

Image processing has been in existence now for many years and has been employed in numerous areas before astronomers began to make use of the possibilities offered by its methods. Radio astronomers, having no actual photographs to look at, were forced to turn to numerical methods of handling their data; as the number of observations increased, improved methods became essential to deal efficiently with the enormous number of measurements on hand. Optical astronomers found themselves in similar situations as soon as certain manipulations of their original data became necessary, such as the transformation of densities on a photographic plate into intensities.

When electronic detectors began to come into use, methods had to be worked out to apply geometric corrections, to correct for image defects, and—when no permanent picture was retained—to have the possibility to view and work with the reconstructed image of the digitized data. As fainter and fainter images started to preoccupy the interest of many astronomers, ways to bring out the contrast in objects, remove noisy backgrounds and sum a number of identical images—to mention just a few—became necessary.

In short, an image-processing system should serve to deal with large amounts of pixels in an efficient manner, to work interactively with the image, and provide the means to view, correct, compare and derive meaningful information by utilizing the statistical contents of the measurements to make visible information that would normally remain undiscerned. Obviously, it is not possible to derive more from measurements that is inherently present, and in this regard care must be taken when manipulating data so as to pre-

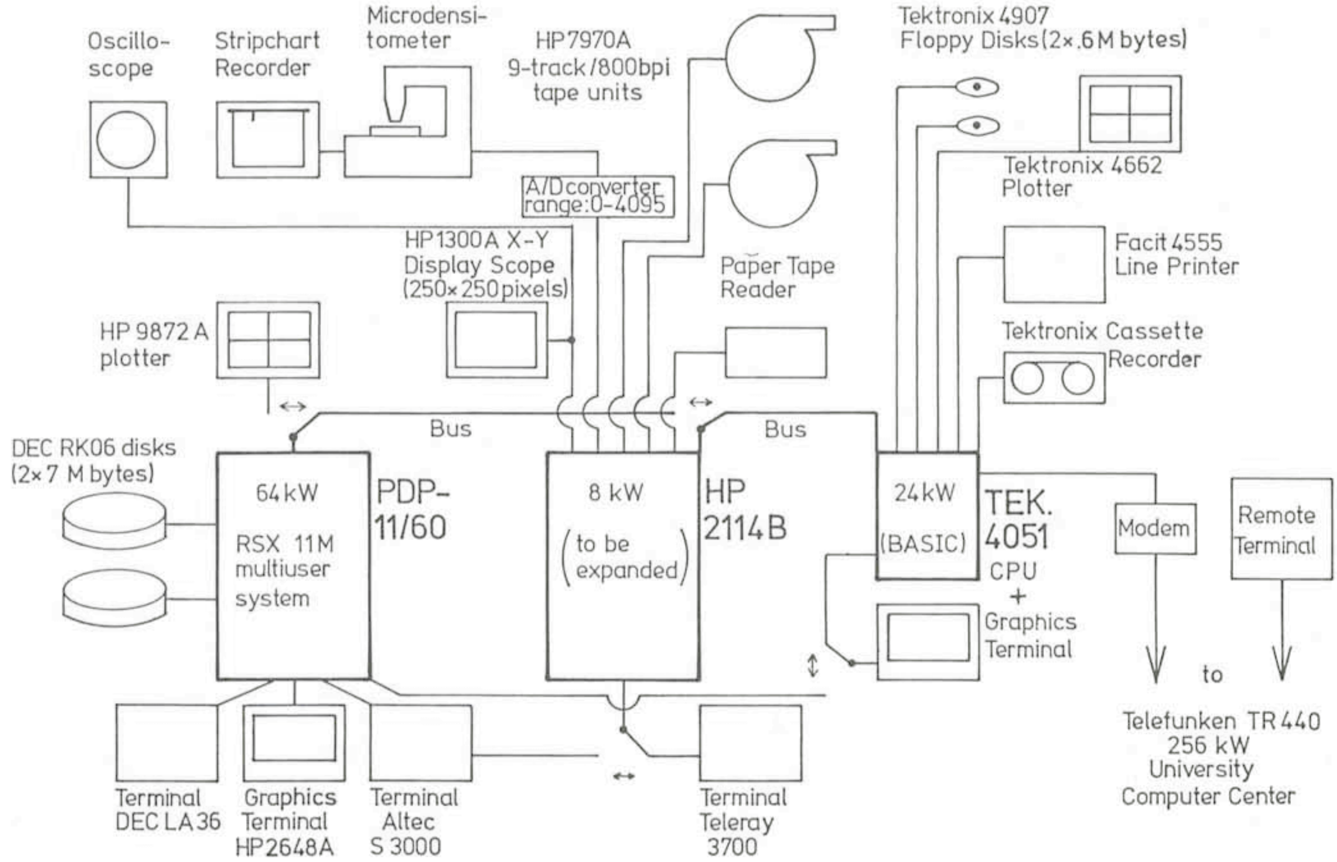


Fig. 1: *The computational facilities at the Astronomical Institute, Bochum.*

vent the loss of information, but also to avoid overinterpretation.

A number of facilities for image processing are in use at our institute and are described here (see figure 1).

Computing Facilities

Microdensitometer: Digitized images can be created directly with the institute's microdensitometer. This instrument, constructed by the Zentralwerkstatt Göttingen GmbH, was originally used for registering stellar spectra. The mounting of a measuring scale and micrometer screw to position the plate in the direction perpendicular to the scan direction (minimum step = 5 μm) enables the user to create, semiautomatically, two-dimensional digitized images, the maximum plate size being 24.5 x 24.5 cm. The dimensions of the slit can be adjusted continuously in a wide range (rectangular as well as square configurations), the minimum area of the slit being limited only by the granularity of the emulsion of the plate.

One example of an object is R 136, which was scanned by slits varying from 10 x 10 μm in the inner, to 40 x 40 μm in the outer regions (Feitzinger et al., 1979). For details on the results, see the article by J. V. Feitzinger and Th. Schmidt-Kaler on page 37. The digitizing of wide angle photographs of the Milky Way (Schlosser et al., 1977) were produced by using a 100 x 100 μm or 200 x 200 μm slit.

After the light has passed through the optics of the instrument, it reaches a photomultiplier, and the signals are sent to the HP2114B computer via an A/D converter. The measured signals of a scanned row are then stored as a record of 12-bit words on magnetic tape. The X-dimension of the scanned image is primarily limited by the storage capacity of the HP2114B, but a memory expansion is being added. Until now, digitized images of up to about 65,000 pixels have been produced. The subsequent data reduction can be undertaken on the HP2114B, Tektronix 4051, PDP-11/60 or at the university's computer centre.

HP2114: It may be surprising that the smallest of these computers, the Hewlett Packard 2114B with only 8 kW of memory, is connected to the other computers, but this is easily explained. The HP was the first computer in our institute and it is now more than ten years since it was installed together with two magnetic tape units, a simple terminal and an X-Y display with 250 x 250 pixels. Even in those "early" days of computing it was thus possible to display and, in a limited way, to process images, as for instance spectra, two-dimensional surface photometry of the Milky Way and measurements obtained with the spectrum scanner used on the 61 cm Bochum telescope on La Silla.

It should be noted that the X-Y display is by no means comparable to a modern graphics display; it possesses no more intelligence than an ordinary oscilloscope, which means that every point has to be programmed—not an easy task for alphanumeric characters. Now, with the graphic capabilities of the Tektronix 4051 and the terminal HP2648A, the old HP computer is only used as a buffer and a controller for the magnetic tape units, paper tape reader and the analog-to-digital converter. But, nevertheless, there are still users of this little machine, which is at least reliable and certainly will profit greatly from the above-mentioned memory expansion.

Tektronix 4051: This graphics system forms an additional facility for data reduction and analysis. Several elements make up the system, the primary ones being the Tektronix 4051 computer with extended memory (programmable in BASIC) and a high-resolution CRT (1024 x 780 points). Data and programmes can be stored on magnetic tape cassettes holding up to 300 kbytes. Additional peripherals include a Tektronix 4907 file manager (a direct access 600 kbyte disk device for storage and retrieval of ASCII and binary data and programmes), a Tektronix interactive digital plotter and a FACIT printer.

An RS232C interface enables the user to operate the Tektronix 4051 as an I/O terminal of the PDP-11/60 or the Telefunken TR440 of the university's computer centre. For data transfer to the HP2114B, an IEC bus interface is provided.

Several software routines have been developed for the 4051 system, including a pseudo three-dimensional plot of an image (Feitzinger et al., 1979 op. cit.), contour maps and several reduction programmes (characteristic curves, etc.).

PDP-11/60: With the installation in January 1979 of a PDP-11/60 with 64 kW of memory, floating-point processor, and dual RK06 disk drives, the possibility of doing interactive image processing became feasible, the turn-around time being an important factor. The link to the HP2114B was established with an IEC bus, the PDP-11 being controller. The bus is also used to operate a four-colour HP9872A flatbed plotter. Two graphics terminals are available: the Tektronix 4051 and HP2648A. The latter can be switched into scaled compatibility mode, allowing it to operate with Tektronix graphics software.

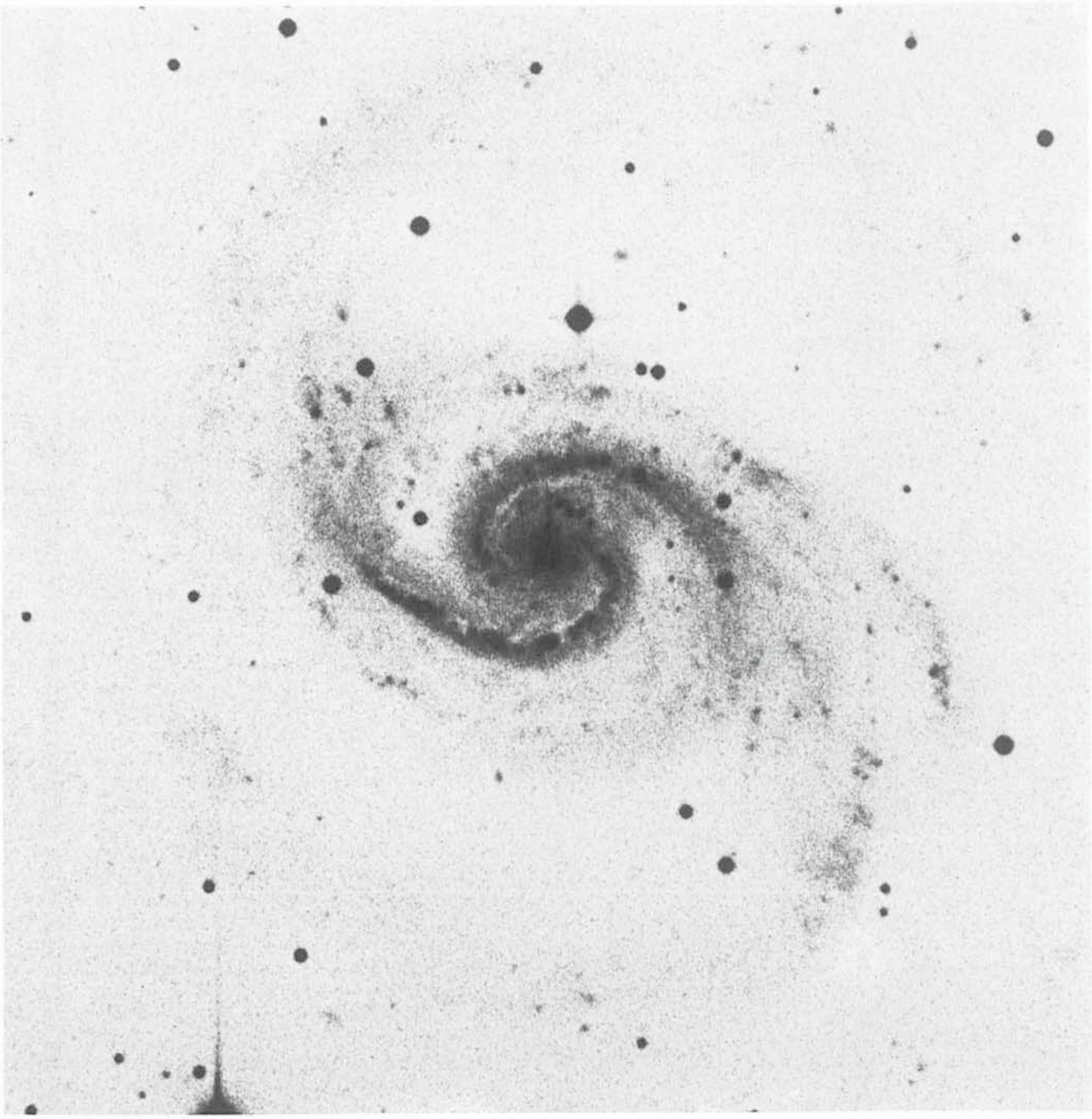


Fig. 2: *NGC 1566 as reproduced from the ESO(B) Atlas.*

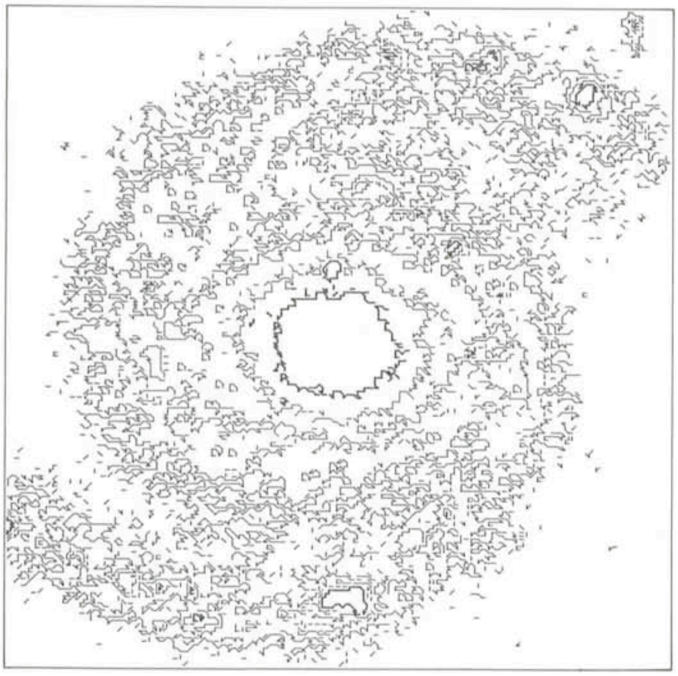


Fig. 3: *Contour map of the original digitized data.*

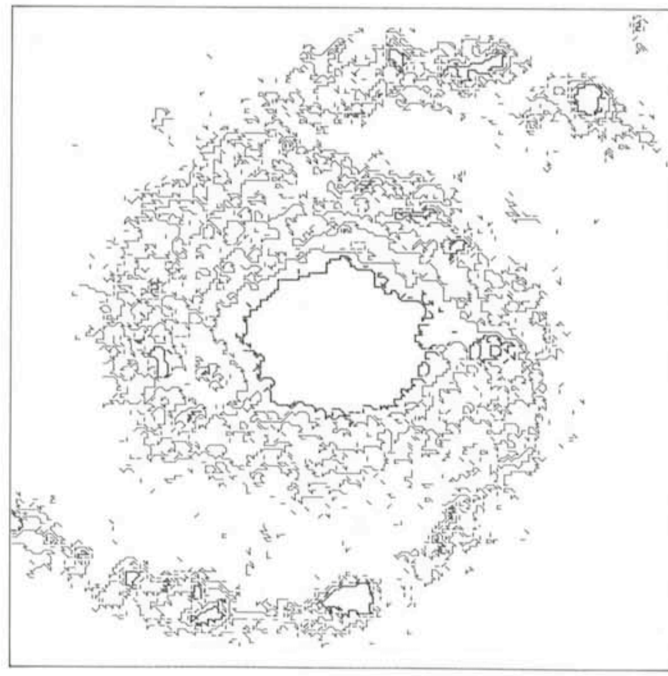


Fig. 5: *The same image as in figure 4, but with different levels chosen to emphasize the features in the arms.*

The Software

The heart of the image processing facilities is the software of the Tololo-Vienna system, developed by S. Schaller of CTIO and R. Albrecht of the Institute for Astronomy, Vienna, Austria. Application programmes have been developed primarily at these institutes; but after they have been obtained by other institutes, people there have become involved in programme development for the system as well. Through the generous help of R. Albrecht and A. Schermann of Vienna, it was possible to transfer the entire system to Bochum in September 1979. Details of the system itself can be found elsewhere (see, for example, Albrecht, 1979).

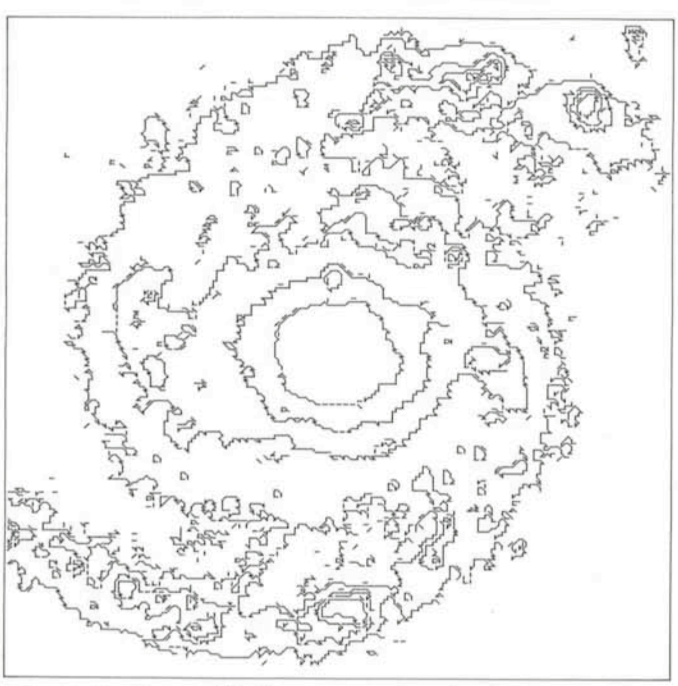


Fig. 4: *As above; with the same contour levels, but smoothed.*

One- and two-dimensional images can be handled very efficiently and interactive work can be realized with relatively short computation times needed for the simpler operations. Moreover, more than one user can work simultaneously. There are already over one hundred application programmes and with the system being open-ended, new routines are continuously being developed. It was already possible to adapt several plotting routines for use on the HP 9872A plotter.

The normal procedure is to send data contained on magnetic tape to the PDP-11 via the bus, which are subsequently stored on disk, modified structurally for integration into the TV-system file structure, and incorporated into the system with the appropriate application programme.

A Working Example

An example of the Tektronix 4051 system's capabilities has already been demonstrated with R 136. Here, we would like to show some of the capabilities as achieved with the PDP-11 and the TV-system. As an object, the Seyfert galaxy NGC 1566 was chosen. A photographic reproduction is shown in figure 2. The digitization of the inner part of this object and the data transfer took place as described above, with 195 x 195 pixels obtained with a 30 x 30 μm slit.

Figure 3 shows the raw data in a pseudo-contour plot. The dynamic range of the image was then scaled down by a factor of two and smoothed with a 3 x 3 pixel filter, utilizing the sigma-kappa method (cf. Newell, 1979).

The suppression of noise can easily be seen in figure 4, which shows the result of these actions. The contour levels are the same as in the previous figure. To bring out details, the image was plotted again (fig. 5) with contour levels chosen so as to emphasize the features in the arms. The clearly developed spiral arms running right into the centre and the extremely narrow dust lanes, interrupted by H II regions, can be seen. Essentially the same details can be seen as in figure 4 of de Vaucouleurs' study of this object (de Vaucouleurs, 1973), his contours being obtained with the McMath-Hulbert Observatory's isophotometer. Finally, figure 6 shows a ruled surface plot of the data. The segmentation of the arms and the compact nucleus are well depicted.

As the future tendency seems to lean towards even larger amounts of digitized data (e.g. from IUE, Space Telescope, CCD detectors, etc.), appropriate facilities will play an even more important role when dealing with this information. With the number of individuals involved in image processing here, the further expansion and refinement of the systems available seems to be justified and many plans for future improvements are being considered.

Acknowledgements:

The help of Drs. R. Albrecht and A. Schermann of the Institute for Astronomy, Vienna, and the administration and staff of CTIO are gratefully acknowledged for the possibility of obtaining the TV-system. Transfer was made possible by the Max-Planck Institute for Astronomy, Heidelberg, for which one of us (TK) would like to thank Dr. H.-J. Röser and R. Tremmel. We would also like to thank Dr. J. V. Feitzinger for conveying to us information on NGC 1566 prior to publication.

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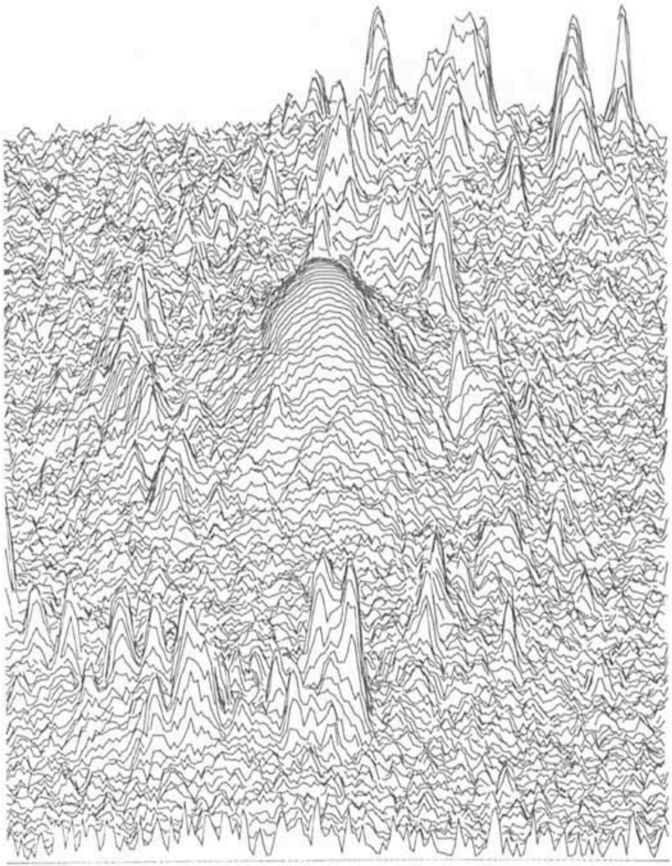


Fig. 6: *A hidden line plot of the smoothed data of NGC 1566. Note the high contrast of the arm structure.*

NEWS AND NOTES

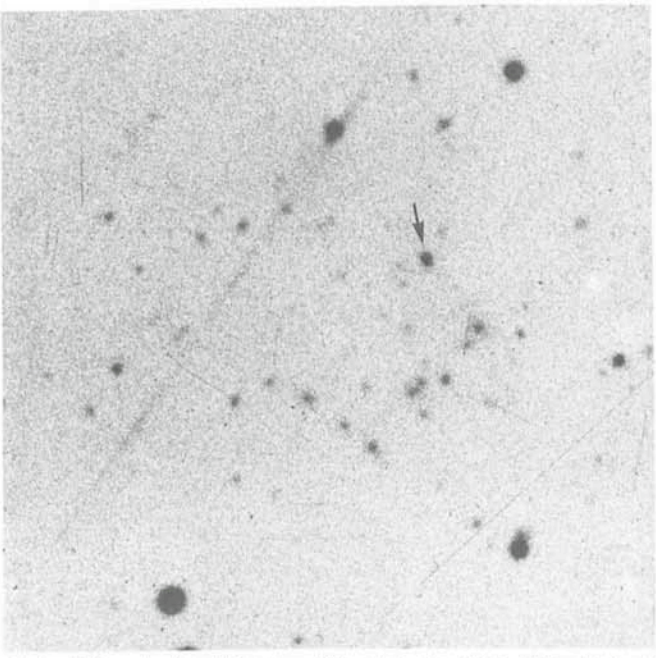
When the Earth was Born

Astronomy offers the unique possibility of looking back in time. Contrary to other sciences, it allows us to see objects as they were a long time ago. This is of course due to the enormous distances in the Universe and the finite velocity of light: around 300,000 km s^{-1}.

With the availability of very deep, red plates from the ESO Schmidt telescope for the red part of the joint ESO/SRC Atlas of the Southern Sky, a group of astronomers has now begun to look for very distant clusters of galaxies. A substantial number of hitherto unknown clusters have been discovered and some of them are in the process of being investigated further.

We here show just one example. A cluster was discovered by Dr. I. Semeniuk two years ago (actually on the SRC J plate). Last month, it was possible to obtain a spectrum of the brightest galaxy in this cluster (see the figure) by means of the new Reticon spectrograph at the Cassegrain focus of the 100-inch du Pont telescope at the Las Campanas observatory. Thanks to the excellent telescope and the powerful spectrograph, it was possible to measure the position of several absorption lines in the spectrum of the $20^m.5$–$21^m.0$ elliptical galaxy (no emission lines were present) and to determine the redshift as z = 0.30. The total observing time was just two hours.

Applying the relativistic correction, and under the assumption that the redshift is a result of motion of this object (Doppler effect),



A blue 3.6 m photo of the very distant cluster 0346–454, obtained under mediocre seeing conditions. A faint artificial satellite crossed the field during the exposure. The galaxy for which a spectrum was obtained as described in the text has been indicated.

the recession velocity is found to be around 76,000 km s^{-1}. Furthermore, with a Hubble constant of 50 km s^{-1} Mpc^{-1}, the distance becomes 1,500 Mpc, or almost exactly 5 x 10^9 lightyears.

The Hubble constant is not known with very high accuracy and this calculation may well be wrong by 20 % or even more. Nevertheless, it is thought-evoking to look at this cluster and to remember that the presently estimated age of the Earth is also close to 5 x 10^9 years. The photons that hit the Reticon spectrograph had been travelling ever since the Earth was formed, just to deliver their message about their place of origin. Without being philosophical, it almost hurts the heart to think about those photons that arrived a few seconds after the shutter had been closed . . .

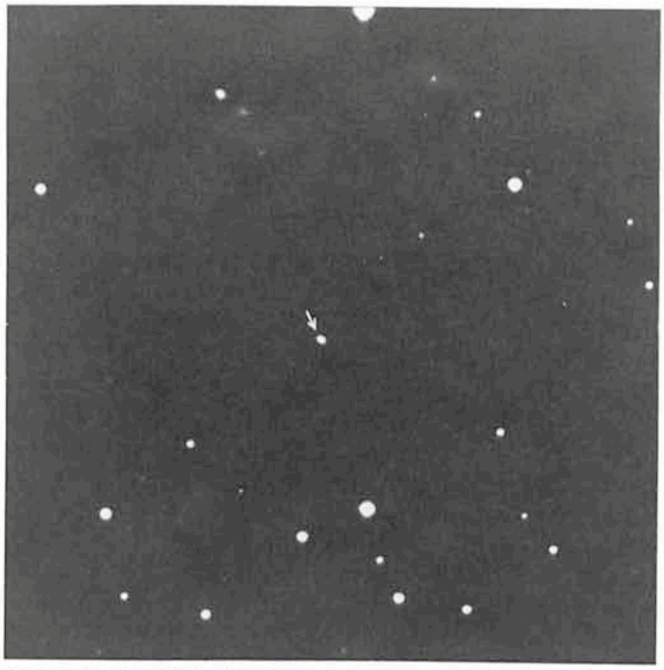
R. West

La Silla in the Sky

Attentive readers of the "Minor Planet and Comet Circulars" from the Minor Planet Bureau will have noticed that the December 1, 1979 issue contains reference to a newly-discovered minor planet, 1976 UH, that has now been numbered (2187) on page 5036 and also named LA SILLA on page 5039.

The dedication reads: "Named after the mountain in the Chilean Atacama desert on top of which is situated the European Southern Observatory." It is interesting to note that the size of the new planet is not too different from the La Silla Mountain, and—in view of the ever-increasing risk of (light and atmospheric) pollution that threatens many observatories (although certainly *not* the ESO establishment at the present time), one wonders whether one is here witnessing an extreme example of very long-term planning?!

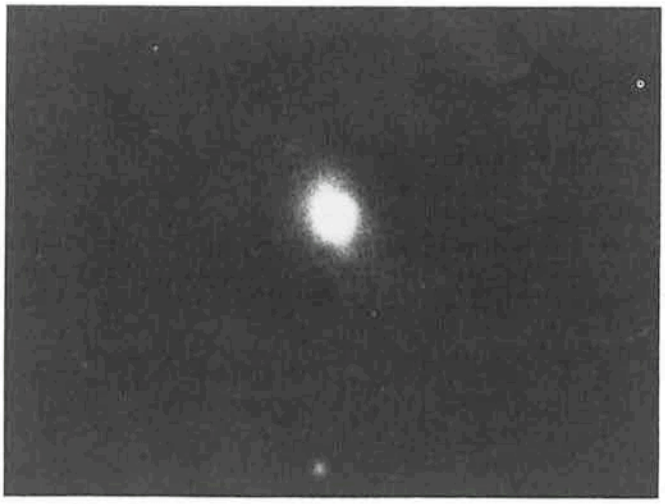
(From our South America correspondent)



Minor planet (2187) = LA SILLA as seen on a recent plate, obtained with the ESO 1 m Schmidt telescope (60 min. IIIa-F + RG 630). The planet was discovered with this telescope on October 24th, 1976 by ESO astronomer R. West.

A New Bright Seyfert 1 Galaxy

Yet another new Seyfert 1 galaxy has been found on the ESO(B) Atlas of the Southern Sky. The object, ESO 012-G21, was first listed in ESO/Uppsala list No. 6 (1978, *Astron. & Astrophys. Suppl.*, **34**, 285) and is here shown in a reproduction from a 30-min electrograph obtained with the 4 cm McMullan camera at the Cassegrain focus of the Danish 1.5 m telescope (La Silla) by Dr. P. Grosbøl.



The galaxy has a rather bright nucleus which is surrounded by diffuse (spiral?) features. UBV photometry was carried out by Dr. C. Sterken with the 61 cm Bochum telescope at La Silla during three nights and a mean apparent magnitude of 14.5 in V was found. Spectra were obtained by Dr. R. West with the 100 inch Las Campanas telescope and the Reticon spectrograph and the redshift was about z = 0.03. With a Hubble constant of 50 km s^{-1} Mpc^{-1}, this gives an absolute magnitude of $M_V \sim -22$. The galaxy is therefore among the intrinsically most luminous Seyferts and, due to its relatively small distance, it is still possible to investigate in some detail the "fuzz" that surrounds the nucleus.

It is not excluded that ESO 012-G21 has been detected as an X-ray source, but due to confusion around this sky area, further observations are necessary to confirm this.

Instrumentation Schedule

This is an updated time schedule for the major instruments which are being developed at ESO in Geneva for use on the 3.6 m telescope. See also *Messenger* No. 15, p. 10. Target date is the date of "first light". Regular use starts about half a year later.

Triplet Adapter (M. Tarenghi, M. Ziebell).

First tests on the telescope were made in September 1979. Further tests will be carried out end November 1979 together with the first tests of the

4 cm McMullan Camera (K. Klim).

Regular use of this equipment by visiting astronomers starts in April 1980. For more details see articles in this *Messenger*.

Coudé Echelle Scanner (CES) (D. Enard, J. Andersen (Copenhagen), A. Danks). Target date: June 1980.

Instrument to record very high resolution digital spectra (up to 100,000) on a 1972-channel-DIGICON or Reticon detector. Availability of Digicon is still uncertain. Double-pass scanning mode permitting calibrations on bright objects with very clean instrumental profile. For more details see *Messenger* No. 11, p. 22 and No. 17, p. 32.

Coudé Auxiliary Telescope (CAT) (T. Andersen, M. Dennefeld). Target date: June 1980.

1.5 m spectroscopic telescope feeding CES of the 3.6 m telescope. Three-mirror alt-alt telescope with f/120 (f/32 after focal reducer). Dall-Kirkham optics with spherical secondary. Direct drive servos without gear. For more details see *Messenger* No. 10, p. 21 and No. 16, p. 37.

Infrared Top-End (R. Grip, P. Salinari). Target date: November 1980.

Wobbling secondary mirror with f/35 in Cassegrain focus, new telescope top-ring which puts radiating material away from light beam. For more details see *Messenger* No. 13, p. 23.

Cassegrain Echelle Spectrograph (CASPEC) (M. LeLuyer, J. Melnick). Target date: end 1980.

Instrument with resolution of 15,000, 30,000 and 60,000 with an SEC-Vidicon detector. Data-reduction process not yet defined in detail. For more details see *Messenger* No. 17, p. 27.

W. Richter

Continuity of Spectroscopic Properties from Nearby Active Galaxy Nuclei to Intermediate Redshift Quasars.

J. Bergeron, D. Kunth

What are quasars? Astronomers have wondered ever since their discovery, more than 15 years ago, as a class of highly enigmatic astronomical objects. Now, however, a better understanding of the physical processes in their interiors is slowly emerging, thanks to improved observations, and it appears more or less confirmed that (most of the known) quasars are actually rather similar to the nuclei of nearby, active galaxies. Correlations between strengths of emission lines and absolute magnitude have been found. Drs. Jacqueline Bergeron and Daniel Kunth of the ESO Scientific Group in Geneva are presently studying the important question of radio-strong vs. radio-quiet quasars and report some extremely interesting observations with the 3.6 m telescope.

The physical properties of the broad-line regions (BLR) of the active galaxy nuclei may be derived from correlations between emission-line ratios or line equivalent widths (EW) and luminosities.

In the past the observed broad emission lines in nearby active nuclei were only those of hydrogen and helium. For these objects, the lack of variation of EW (Hβ) with the absolute magnitude M_v (however with large scatter) found by Searle and Sargent (1) in 1968 favours optically thick, photoionized models for the BLR.

Shortly after the first report of the presence of Fe II emission in the spectrum of the quasar 3C273 by Wampler and Oke (2) (1967), it was widely recognized that Fe II emission had been overlooked in the optical spectra of Seyfert galaxies for many years. The chief reason was that the bulk of emission does not arise from one individual line, but is spread into many distinct multiplets. Moreover, synthetic spectra produced to fit the observed ones could show unambiguously that the intrinsic width of each line is as large as the broad Balmer lines. These reasons all together explain why Fe II emission was difficult to detect on uncalibrated photographic plates.

Subsequent investigations of Seyfert 1 galaxies by Osterbrock (3) have shown that all the known Seyfert 1 indeed have broad Fe II emission features.

The Fe II Emission Lines

What does Fe II emission tell us about the BLR? We know from its atomic structure that Fe^+-ions can only exist in regions that are well shielded from the near UV-continuum source. Therefore the Fe II emission is characteristic of regions of very large absorbing column density and high optical depth in the UV.

For quasars, Baldwin (4) derived, from surveys *involving different redshift ranges,* a composite spectrum assuming a continuity of spectroscopic properties between low and high redshift quasars. He could predict relative intensities of optical and UV lines, in particular a ratio Lyα/Hβ around 2–6, one order of magnitude smaller than expected from pure radiation recombination origin.

This continuity was confirmed by UV observations of active nuclei and low redshift quasars (5) and IR data of distant quasars (6).

However, from existing observations a difference was suggested by Philipps (7): although optical Fe II emission is characteristic of Seyfert 1 galaxies, it was uncommon in his survey of 20 quasars of low redshift (at $z < 0.70$).

We had the feeling that some observational bias in the sample selected by Philipps was at the origin of this difference. His observed quasars were strong radio sources, similar in some way to nearby broad-line radio galaxies. The weakness of optical Fe II emission in a large fraction of these radio galaxies, known since the observations of Osterbrock et al (8), rather suggests a continuity between the *broad-line radio galaxies* and the *radio quasars.*

Observations of nearby *radio-quiet* quasars thus appear necessary to investigate the continuity between Seyfert galaxies and radio-quiet quasars. We therefore decided to observe a fair sample of quasars known to be radio-quiet at the limit of detection of the Parkes survey; unfortunately no large optical surveys have been carried out for the redshift range we were interested in. Objects do exist however; most of them come from the Haro-Luyten catalogue or from the recent R. Green survey of bright QSOs.

Bergeron (9) and Kunth and Sargent (10) found a well-defined (increasing) upper limit of EW (Fe II) versus M_v. This trend is different from the constancy of EW (Hβ) and points towards the existence of different mechanisms for Hβ and Fe II emissions. For high-redshift, radio-flat quasars (high luminosity objects) the correlation between EW (CIV) and the UV luminosity (11) is inverse to that found for Fe II. It favours an optically thin emission region for the higher excitation lines. Nearby radio quasars of high luminosity as 3C 273 (5) follow this relationship, but lower luminosity, active nuclei such as NGC 4151 or 3C 390.3 have substantially lower values of EW(CIV) than predicted by the quasar relationship.

Our quasar survey would allow to study the relationship between EW (Fe II) and M_v at higher luminosities and to check whether a break in the Fe II correlation occurs between nearby active nuclei and radio-quiet quasars, as it seems to occur from the broad-line radio galaxies to the radio quasars for the CIV correlation.

To extend the relation between EW (Hβ) and M_v is also of great interest. If the lack of correlation between EW (Hβ) and M_v is valid in the luminosity range where the CIV holds, then CIV and Hβ emission would not arise predominantly in the same parts of the BLR.

3.6 m Observations and Preliminary Results

The observations were performed at the 3.6 m telescope at La Silla, August 1979, with the IDS attached to the Boller and Chivens spectrograph. Preliminary observations on one object in March 1979 led us to select a 600 l/mm grating, giving 114 Å/mm dispersion. The same grating was used for the blue range λλ3700–5900 Å and the red range λλ5500–7700 Å. Direct sky subtraction can be performed on

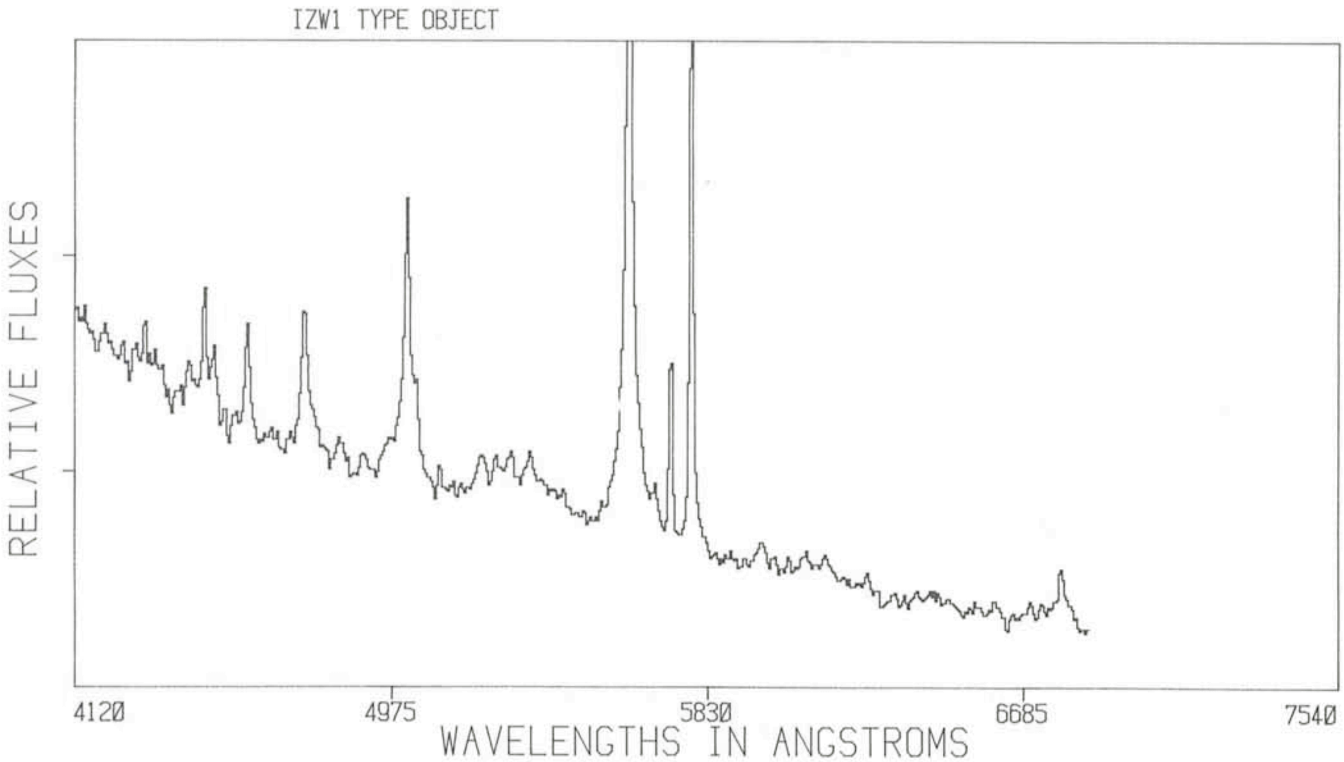


Fig. 1: *The spectrum of one of the quasars that were recently observed with the 3.6 m telescope and the IDS. Note the strong lines of [O III] and Hβ in emission (near centre of figure) and the numerous, much weaker Fe II emission peaks on either side of these three lines.*

the IDS and it is therefore quite suitable when one looks for faint, broad features of low contrast against the continuum. Hopefully, these observations will allow to answer some of the questions mentioned above.

From a preliminary look on the data we can already now foresee some new results. We wish however to stress that some of the numbers given below are only approximate and may be somewhat changed after complete reduction of our data.

Contrary to Philipps' (7) conclusions, we find that a large fraction of the quasars from our sample (23 objects) are FeII emitters. For the radio-quiet quasars the proportion is very high (9 out of a total of 11), and the strongest observed FeII emissions are found among them. For the radio quasars the ratio is still important (6 out of 12), with at least half of the FeII emitters being flat radio sources. This trend should be confirmed on a larger sample, since some strong radio-flat quasars do not show any substantial emission.

These results strengthen the link between Seyfert 1 galaxies and radio-quiet quasars and give further support to the identification of radio-quiet quasars with spiral galaxies, since most (if not all) Seyfert 1 galaxies are spiral galaxies (12).

One of our objects has a typical Seyfert 1 spectrum, yet with small line widths. The FeII multiplets are well resolved as shown in figure 1. This occurs only rarely in Seyfert galaxies. A comparison with I Zw1, the most studied Seyfert 1 "narrow-line" galaxy, will allow to estimate the variability among the FeII multiplets (in particular multiplets 27 and 28 relatively to the other multiplets). This may help to identify the FeII exciting agent.

Correlations

Only very rough statements can yet be made on possible correlations involving equivalent widths. Our range of absolute luminosities overlaps with Baldwin's (8) survey of radio quasars and with our studies (6) (7) of FeII in Seyfert galaxies.

The lack of correlation between EW(Hβ) and M_v found for Seyfert galaxies seems to extend towards larger luminosities.

Among the radio-quiet quasars, we have found 3 objects with very strong FeII emission. We will thus be able to extend the relationship EW (FeII), M_v at larger luminosities, but cannot say yet whether a break in the relationship occurs or not.

The spread of full-width half maximum (FWHM) for the permitted lines is large. Only a small fraction of our objects have very large FWHM. Furthermore, the larger the line, the more asymmetric is the profile. There does not seem to appear any trend of increase of the line width with increasing luminosity as suggested by A. Wilson.

More observing runs are necessary in particular to extend our preliminary relations to higher luminosities and to improve the statistics of the radio FeII emitters QSOs.

It will also be interesting to fill the gap and to try to find a unique property valid on a large-z sample.

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A Supernova Search with the ESO 1 m Schmidt Telescope: Greatly Improved Efficiency

A. B. Muller

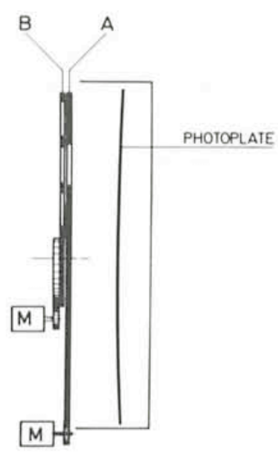
Supernovae are astrophysically extremely interesting objects. It is presently believed that most, if not all, heavy elements are created when stars explode as supernovae. About ten supernovae are presently discovered each year and much thought has been given to the problem of discovering new supernovae as early as possible after the rise in luminosity, in order to study the physics of such objects in their initial phases.

Dr. André Muller from ESO has conceived many ingenious technical solutions to a wide variety of problems. In this article, he describes a new device for the quick and efficient detection of supernovae with the ESO 1 m Schmidt telescope. The results of the first practical tests of this method will soon be available.

While investigating the possibility to start a routine supernova search programme with the ESO 1 m Schmidt camera, it soon became clear that it was all-important to find an efficient and economic observational method with a minimum of waste of time and photographic material. For many reasons the study of supernovae is a very important subject. However, to be able to observe newly-discovered supernovae with medium-size telescopes equipped with photometers and spectrographs, they must be rather bright, and it was therefore decided to search only for stars apparently brighter than the fifteenth magnitude. This decision once taken, the question then arose how one can photograph a great number of galaxies in an economic way with a Schmidt camera.

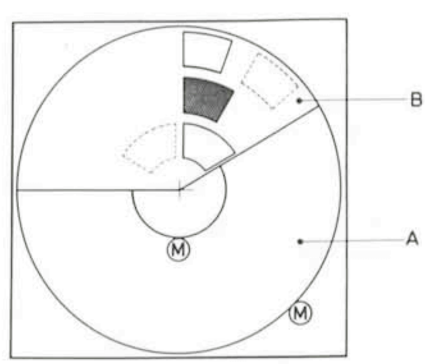
After some thinking, a viable solution was found in the form of a double diaphragm device which divides the 30 x 30 cm^2 photographic plate into a number of circular zones and each circular zone into a number of sectors.

How this is done can be seen in the drawing. The utilization diagram shows one of the possible ways of dividing the photographic plate. In this special case the plate is divided

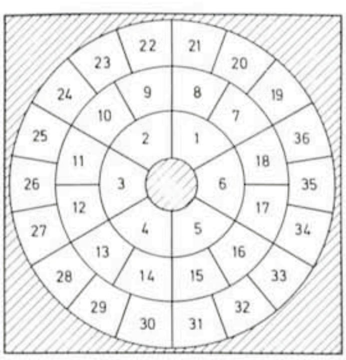


SIDE VIEW

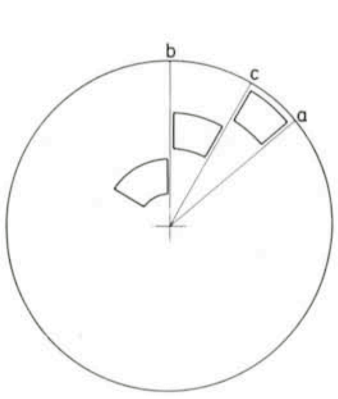
DISK A+B, FIELD Nº8 OPEN



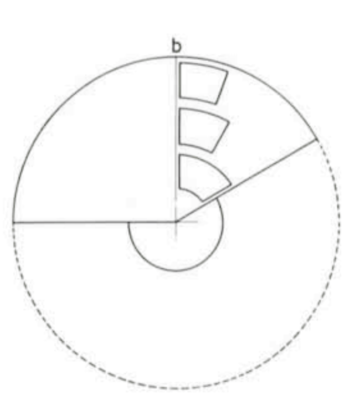
TOP VIEW



UTILIZATION OF THE PHOTOPLATE



DISK A



DISK B

into three circular zones. The inner zone is divided in 6 sectors (1–6), the second zone into 12 (7–18) and the third into 18 sectors (19–36) defining a total of 36 areas on the plate, each measuring about 45 x 47 $arcmin^2$.

In its present form, the diaphragm device consists of two components: the diaphragm disk A and the sector B which are mounted on top of each other and can be rotated around a common, perpendicular axis. Sector B rotates with respect to A by means of a motor M, mounted on A. When for instance line b on B coincides with line b on A we have access to field 8 as shown in the top view of the drawing, i.e. field 8 is "open", while all other fields are "closed". A second motor mounted at the edge of A rotates both components A and B to make other parts of the plate accessible. In the given example A and B together can move to 12 different positions covering the full second zone. When b on B coincides with c on A, the third zone with 18 fields becomes available. The disk and sector are mounted in a fixed frame which is attached in front of the plateholder. Diaphragms of different designs can be mounted in this frame so that, if desirable, also larger fields can be observed. The fields are vignetted towards the edges because of the distance of about 38 mm between the device and the photographic plate, defined by the position of the shutter with respect to the plate. In case of the f/3 ESO Schmidt, vignetting starts at about 7 mm from the field edges. However, the chosen exposure-time is such that well-exposed images of 15th-magnitude stars are obtained to about 2 mm from the field edges. The dimensions of the diaphragm holes assure that 100 % vignetting occurs along the lines shown in the utilization diagram, in order to avoid field overlap.

Observational Procedure

The procedure is now simple. When the object in field 1 has been exposed, the telescope moves to the next object (the offset must of course be calculated in advance). Meanwhile the diaphragm device rotates to its next position and field 2 is exposed and so on till field 36. With 5 minutes exposure-time per field and 1 minute between successive settings, 36 galaxies can be acquired in just over three and a half hours. In this way the images of 36 galaxies and their surroundings are collected on one plate only and only one plate has to be developed. In this straightforward way, we avoid the repeated loading of the plateholders, the returning of the telescope to plate loading position, the going to the next object from loading position and the repeated plate development. The gain in time is very important. The gain in material is equally impressive: a large reduction of photographic plates and much less chemicals are used in the plate processing.

The same observing sequence is repeated 10 to 14 days later, independently of the moon-phase, because of the short exposure-time. From this second plate a positive copy is made and placed on top of the previous negative one. As one can only discover the supernovae when they brighten, white images as seen through the combined plates are possible supernova candidates and need verification. If it turns out that plate errors are a serious problem for the certain discovery of supernovae in this way, one could repeat the exposure of each galaxy on the same plate. This yields only 18 instead of 36 galaxies per plate, but the gain in certainty may justify this method. However, this is one part of the practical tests of the method which will be realized within short.

Depending on the available telescope time, 72 or 108 galaxies can be taken in one night and thus be kept under routine control. In order to observe regularly as many galaxies as possible, a joint programme with other Schmidt telescopes could turn out to be fruitful.

Other Possibilities

The diaphragm device can also be used for photometric purposes. Known photometric sequences can be collected on one plate together with unknown fields for calibration. With suitable emulsions the different filters can be shaped to cover each one diaphragm of sector B, enabling photometry in different colours on one plate. The advantage is that all exposures are free of the sky background of the previous exposures and are developed under exactly the same conditions. One must of course carefully avoid the vignetted edges.

Assembling and detail drawings of the diaphragm device are available at request from the author at the ESO-Garching address.

In the Mail...

Dear Editor,
Since the *Messenger* is evolving in the direction of serious journals, one should consider the problem of quoting articles in lists of references. The other day I found the reference: "ESO Mess"—which is perhaps not the best compliment to the otherwise fine organisation . . . H.D.

Dear Reader,
Thanks for your very pertinent remark and for beginning to take this journal seriously—hopefully not too *seriously. You are right about the lack of guidelines for abbreviations of the names of journals. Unless the editors of other journals object, I suppose that "ESO Messenger" will do as reference—at least in this journal . . .*
The editor of the ESO Mess.

Dear Editor,
Why do you not print a table of contents on the first or last page of the *Messenger?* It is always a hard job to find a particular article which appeared some issues ago . . .

R.W. and M.H.U.
(*not* the editor)

Dear Colleagues,
That there so far has been no table of contents (and no index), is due to a subtle psychological trick. In other journals, the reader first studies this table and decides that there is nothing of interest. He then throws it away without having seen what is inside. In the Messenger, *however, he is forced to look through the* entire *issue to be sure that he did not miss that most important article! Nevertheless, you may be right, because as was already written in* Messenger *No. . . . No. . . . (sorry, I can't find it), well, anyhow . . . we shall begin with this issue. OK?* *R.W. (the editor)*

Data Reduction Facilities Available at ESO in Geneva

P. Crane

Nowadays, the astronomer is likely to spend more time at a computer terminal than at the telescope. To assure efficient reduction of the photographic plates from ESO and other telescopes, fast measuring machines have been provided at ESO/Geneva, together with advanced computer programmes for handling the large masses of data that result from these machines and other instruments. Dr. Philip Crane, who is in charge of the system, describes the present configuration and explains how visitors can request time.

The facilities currently available in Geneva fall into two categories: measuring machines and an interactive reduction programme on the Hewlett Packard computers. These facilities are generally available with priority given to observers with data obtained at ESO telescopes in Chile.

Measuring Machines

The measuring machines comprise on Optronics S 3000 scanning microdensitometer, a Perkin Elmer PDS 1010 A scanning microdensitometer, and a one-dimensional Grant machine which can be used either to scan spectra or to measure spectra manually. Each machine is controlled by a small computer which can be used in stand-alone mode or linked to a central Hewlett Packard computer running the RTE IV operating system. Figure 1 shows this configuration.

The Optronics machine is useful for scanning large plates and for making precise astrometric measures on plates. The machine has enough travel in both x and y to be able to scan the large 36 cm square Palomar and SRC Schmidt plates. The electronics can handle densities up to about 3 and the stability is quite good. Scanning speeds of 10 mm/sec are possible. The mechanical stability and linearity of the system are extremely good. The deviations from linearity are less than 1 micron over the entire travel and there is less than 0.5 micron of hysterisis. Several useful computer programmes exist for doing astrometric reductions on this system.

The PDS machine has only recently been installed. It is a complement to the Optronics since it is able to scan higher density plates at higher speeds. However, the mechanical stability and readout resolution are less than that of the Optronics. The PDS has only a 25 cm travel in x and y. The PDS appears considerably easier to use, although experience is still rather limited.

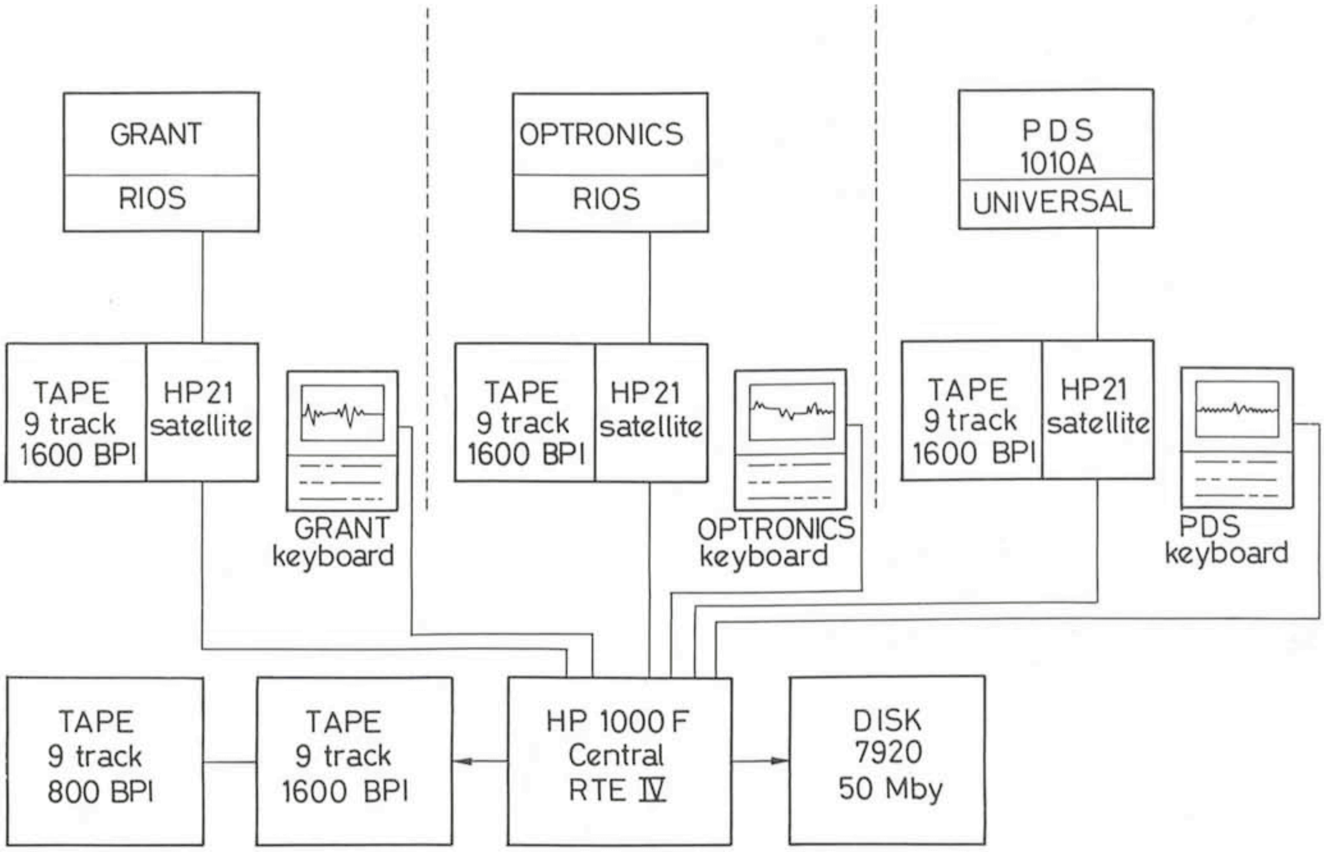


Fig. 1: *ESO measuring machines general organization.*

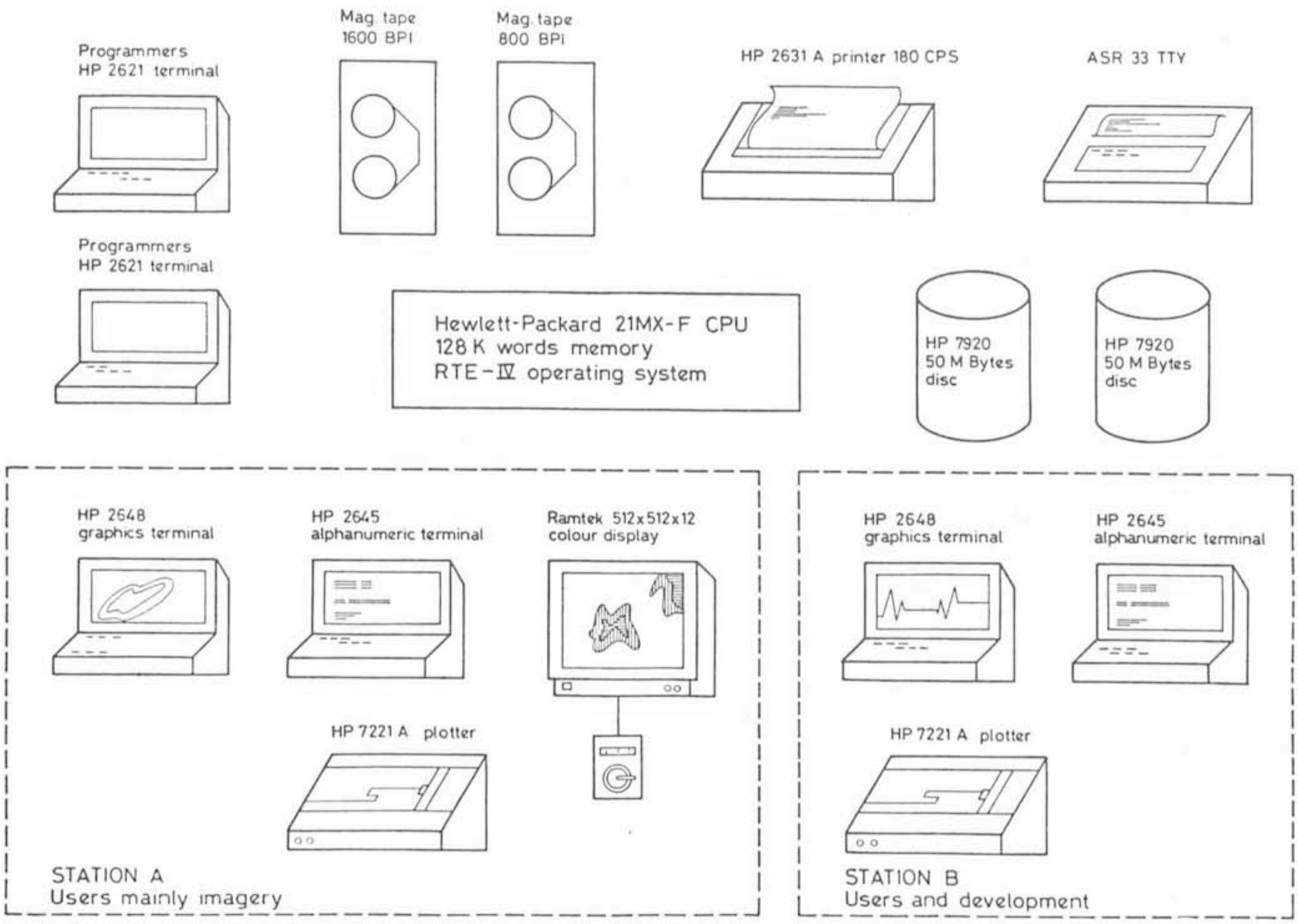


Fig. 2: *ESO main image processing facilities.*

The Grant machine is the one that used to be at ESO in Chile and was shipped to Geneva. For manual measurements of the line positions, good facilities exist to increase the speed and efficiency of the measuring. In particular, a list of the positions of comparison lines and object lines can be entred so that the machine will move automatically to the approximate position of the lines of interest.

When using these machines in the linked mode (i.e. linked to the RTE system), the user can review the data obtained in an on-line way. A small portion of the data is transferred to the central RTE system disk and then the interactive reduction programmes can be used to review the results before setting off on a long series of scans.

In addition to the above devices, there is also a blink comparator which can be used for plates as large as Schmidt plates. There are several smaller manual measuring engines as well as light tables with a travelling microscope.

The output from the scanning machines is in the form of a magnetic tape written on 9 track 1600 bpi form. The data format is an ESO internal one which is well documented. In addition, programmes are available to transform the data into the new FITS (Flexible Image Transport System) format tapes.

Documentation on the measuring machines and programmes available is being written and will be ready by January 1980.

Image Processing

The interactive reduction programmes have been developed to reduce various types of data. The most extensive programmes available are for reducing spectra of various types, but some facilities for two-dimensional photometry do exist and others are under development. Programmes are available to reformat tapes into the ESO internal format for tapes from several different sources. Of course, data obtained on La Silla are already in the proper format. However, IUE data tapes, IPCS tapes, and various tapes from Kitt Peak can be processed. In the future, tapes written in FITS format and ESO internal format will be supported.

Figure 2 shows the hardware configuration of the main system. There are currently three work stations available. Users enter commands from the terminal or use the preprogrammed soft-keys to enter commands. It is also possible to make macro-like commands by stringing together a series of commands into what is called a "Batch" file. All commands operate sequentially, and it is not possible to start up background image processing jobs to run in parallel with the interactive programme.

The repertoire of commands available is growing as well as the demand on the system. Many people are successfully reducing their data with the system. Nevertheless the limitations of the current facilities are becoming clear and it is hoped that soon after the move to Garching, it will be

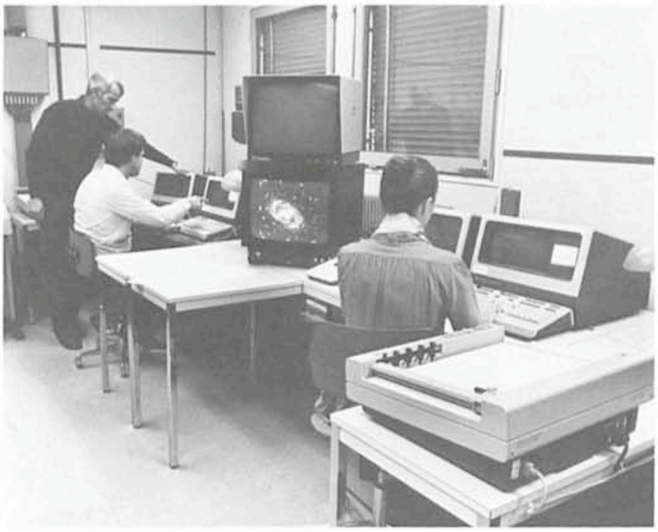


Fig. 3: *The ESO-Geneva image processing room (detail).*

possible to offer more extensive and better services. In the meantime, the development of the applications programmes will continue.

Scheduling and Availability

The measuring machines can be reserved up to 6 hours per day Mon-Fri between 08.00 and 24.00 and up to 30 hours per week. Weekends and the "graveyard" shift (00 to 08.00 hours) do not fall in these restrictions. Normally Thursday mornings are used for maintenance if needed. Visitors should request time at least two weeks in advance. The interactive computer reduction system is scheduled in a similar way except that only 4 contiguous hours per day can be scheduled and up to 24 hours per week. Tuesday afternoons are used for computer maintenance. These are the general guidelines but there is some flexibility if justified.

The procedure for requesting the use of these facilities is to write to the Scientific Group Secretary, Mrs. Renate van Doesburg, ESO c/o CERN, CH-1211 Geneva 23, Switzerland, and to specify the following: (1) Name (should be both the individual who did the observing and the one who will actually use the machines) and address. (2) Nature of the reductions (radial velocities of coudé plates, IDS reductions, astrometry on Schmidt plates, etc.). (3) Machines requested and time required. (4) Accommodations needed (CERN hostel (if available) 16 SFr./night or Hotel about 60 SFr./night or other). Visitors who come to reduce data obtained at La Silla may have their travel and subsistence paid by ESO. This support is normally limited to a maximum of the return travel cost and 5 days subsistence at 105 SFr./day. Observers reducing data obtained at la Silla and requesting ESO support should specify during which observing period their data were obtained. Other visitors should make a more detailed discussion of their project similar to an observing request.

It is the ambition of the ESO staff to provide excellent data-reduction facilities to the user community. This is not a one-way effort. Comments, complaints and, above all, constructive suggestions will be most welcome.

The 4 cm McMullan Camera for the 3.6 m Telescope

Klaus Klim, ESO-Geneva

The testing in Geneva of the 4 cm McMullan Camera for the 3.6 m telescope was completed by the end of September 1979 and it is planned to ship the camera to Chile in November where tests on the telescope will be performed.

The McMullan Camera for the 3.6 m telescope is similar to the camera used on the Danish 1.5 m telescope. A detailed description of the tube and its specification can be found in *Messenger* No. 17: Collaboration on the use of the 4 cm and 9 cm McMullan Electronographic Cameras at the Danish 1.5 m telescope.

The system for the 3.6 m telescope is composed of 3 parts:

- Control Cubicle,
- Camera Unit,
- Cable, vacuum-line and N_2 supply tube.

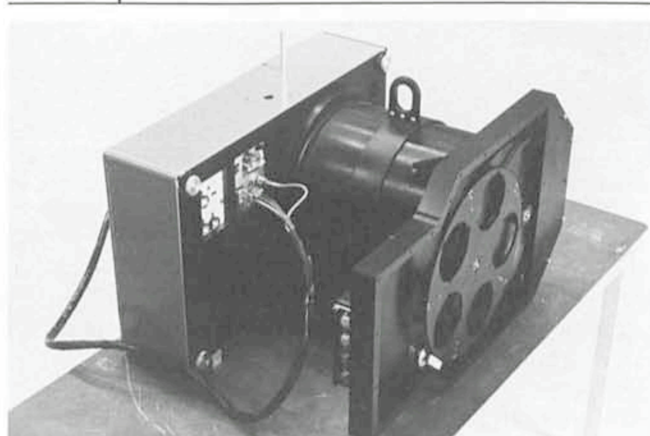
In order to facilitate operation and to increase reliability, it has been decided to install the Control Cubicle in the Cassegrain Cage and to leave the cable permanently on the telescope structure.

This will avoid damage to the vacuum-line which can have a disastrous effect on the tube. The Camera Unit is normally stored on the platform and mounted on the Triplet Adapter for operation (see *Messenger* No. 16).

The Camera is equipped with a filter-wheel and a shutter. The filter-wheel has 5 positions.

Available filters are:

Filter	Composition
U	1 mm UG2 + 5 mm $CuSO_4$ (100 %)
U'	1 mm UG11 + 2 mm BG38
B	1 mm BG12 + 1 mm BG18 + 2 mm GG385
V	2 mm GG495 + 1 mm BG18
R	2 mm OG570 + 2 mm KG3
I	2 mm RG9
Clear	UK50 or UBK7



The 4 cm McMullan Camera for the ESO 3.6 m telescope.

The filter-wheel and the shutter can be controlled either by means of a Handset mounted on the Camera Unit, or through the Triplet Control Panel. The "Load" and "Unload" procedure of the film can be started by the Handset or at the Control Cubicle in the Cassegrain Cage.

The first test period on La Silla will commence on 1 December 1979. The primary task is to test all mechanical and electronical connections to the Triplet Adapter. Thereafter follow acceptance tests of the tubes both under darkroom conditions and with the camera mounted on the Triplet Adapter.

Scheduled release date for the 4 cm McMullan Camera is 1 April 1980.

PERSONNEL MOVEMENTS

ARRIVALS

Geneva:

Jean PAUREAU (French), Mechanical/Cryogenics Engineer, 1.12.1979

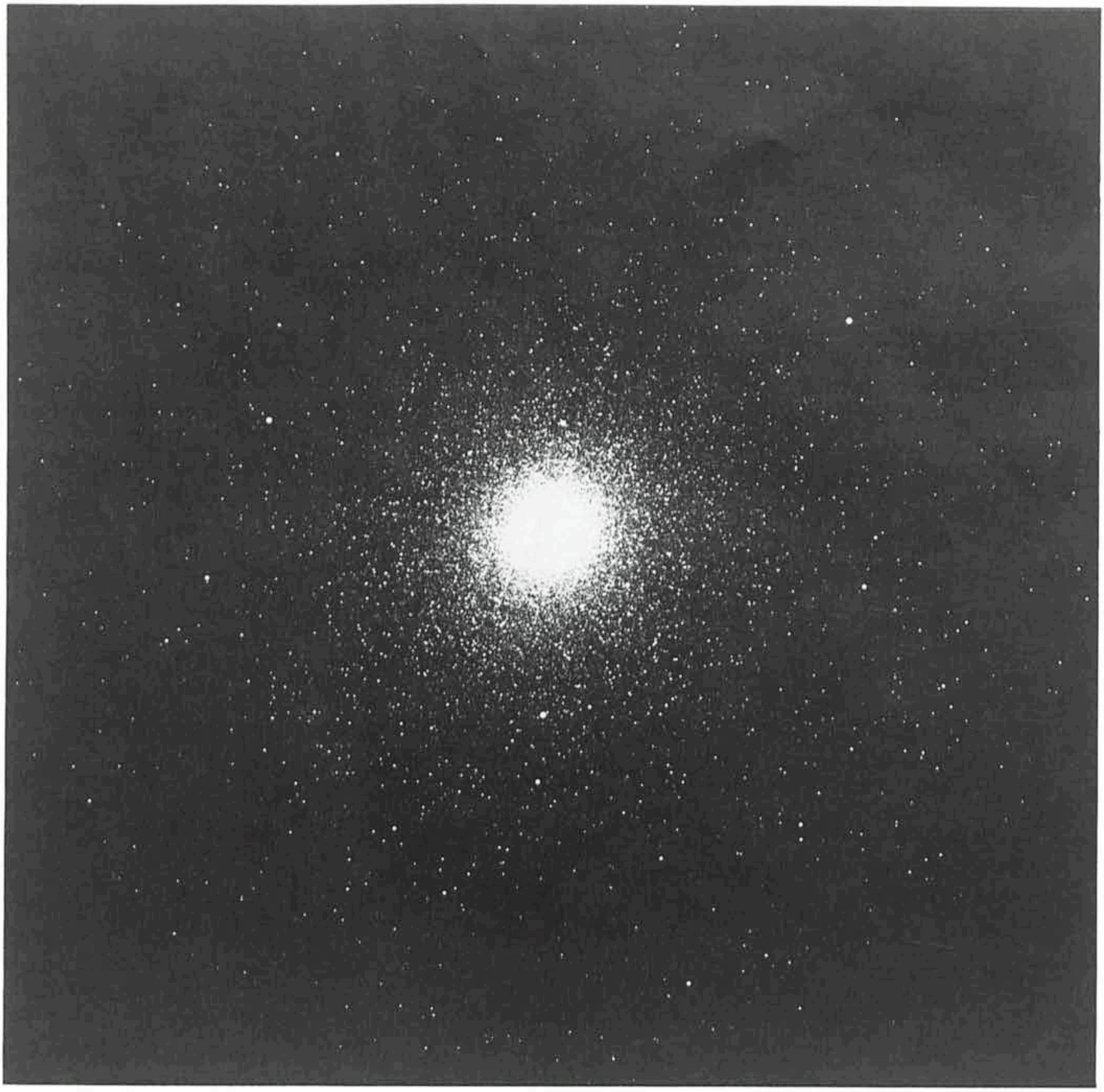
Garching:

Ruthild GRÖGER (German), Junior Secretary, 1.10.1979

DEPARTURES

Geneva:

Bernard AMRHEIN (French), Electronics Technician, 31.1.1980



One of the first test exposures obtained with the triplet at the prime focus of the ESO 3.6 m telescope. It shows the well-known southern globular cluster 47 Tuc. Exposure time 15 minutes on IIIa-J emulsion; no filter; blue corrector. Observer: M. Tarenghi.

3.6 m Triplet Adapter: Tests on the Telescope

Massimo Tarenghi and Manfred Ziebell, ESO-Geneva

The first test installation of the triplet adapter on the 3.6 m telescope took place on La Silla in September 1979.

During this period we obtained a number of focus plates and a few test photos from which a large amount of information was derived about the optical quality and the mechanical and electronical performances, cf. the illustration on page 34.

The results were good: the optical quality is inside the specifications. No problems were found regarding stability and reproducibility of the electro-mechanical functions. The automatic filter and plate changer behaved well despite some problems we had before, during the tests in Geneva.

The problems encountered at this first trial on the telescope were:

(a) The mechanical interface of the adapter to the telescope did not fit.

(b) The range of the axial movement of the knife edge had to be displaced.

(c) The TV camera used for manual guiding was not reliable at low temperatures.

(d) A new version of the 3.6 m telescope control programme, more flexible and more suitable for the integration of the triplet adapter programme and for future implementation, had to be installed.

In order to solve these problems and to offer the triplet adapter for the period 25 (1 April–1 October 1980), a new series of tests is planned for the end of November 1979.

During this second test period we intend to do:

(a) The final alignment of optics (blue and red).

(b) The tests of the guide probe, to determine the values for the use of the "Foucault method".

(c) The determination of the light attenuation in relation to film material, filters and exposure time for the spot sensitometer.

(d) The determination of limiting magnitude.

(e) The tests for ghost images.

Documentation about the triplet adapter will be available at the ESO Libraries in Geneva and on La Silla:

I. General description and specifications: from November 1979;

II. Operations Manual: from February 1980;

III. Maintenance Manual: from May 1980.

Brave New World?

To observe with a telescope is not exactly what it has been. Not so long ago, the astronomer worked next to the telescope, pushed the buttons, watched the sky through the dome slit and entertained the night assistant with his personal repertoire of songs, frequently ranging from the tragedy of *Tosca* to the invocative expressions of "Let it be, let it be" or even later masterpieces.

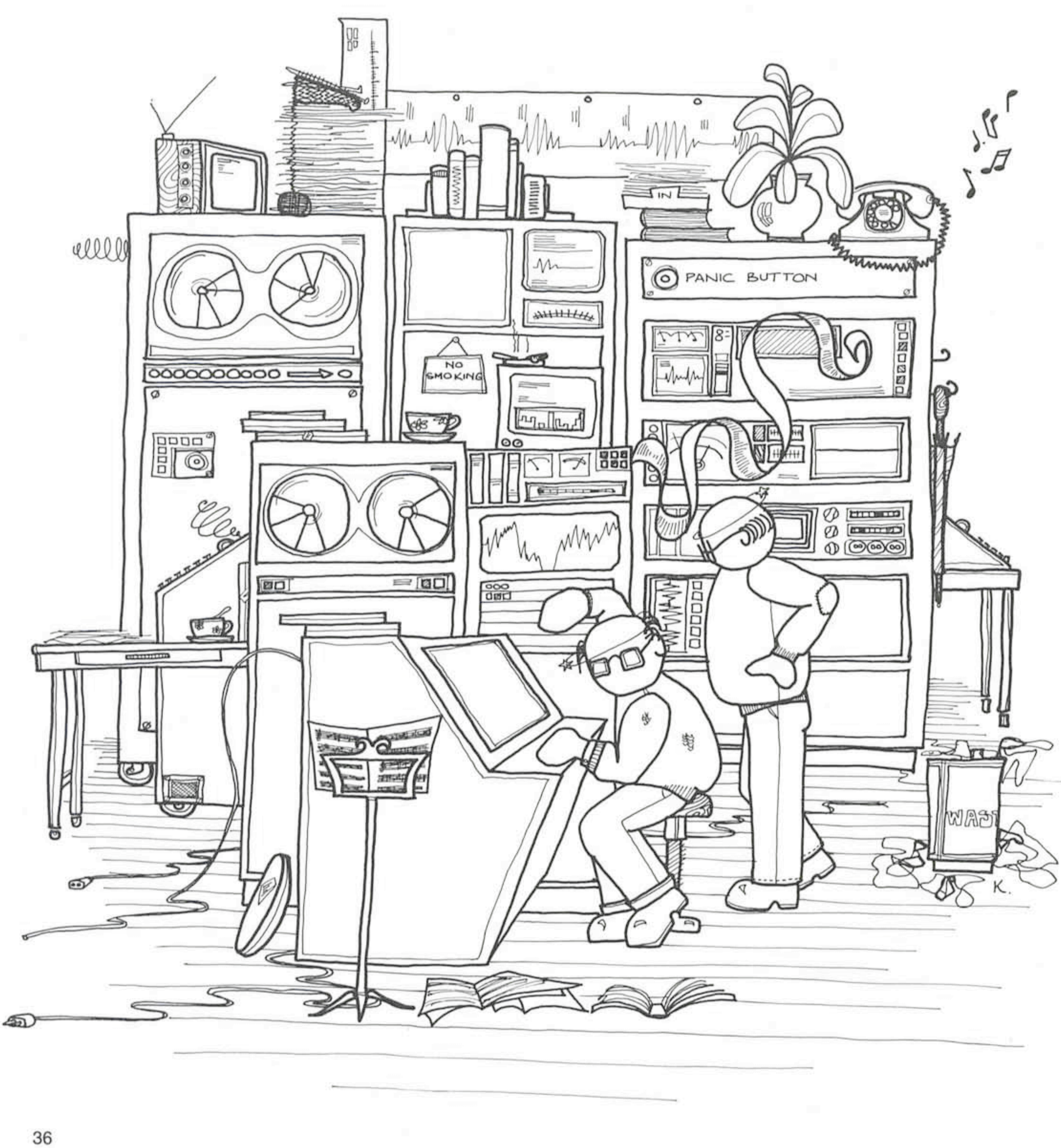
Nowadays, however, in the Age of Automation, the "observer" sits in a brightly lit room, somewhere in the telescope building (he is not quite sure where), and punches the keys of a computer console. He does not know where the telescope is (it may be in space) nor has he any idea of how it looks like. He only worries about the 1/2 night that has been allocated by the Observing Programmes Committee for his observations and whether the telescope and the weather will permit him to obtain the data he has been waiting for during the past year with so much expectation.

The present trend is towards even more automation, even better efficiency, etc. What will it be like, 5 years from now? Always ahead of its time, THE MESSENGER has obtained a listing of a future file in the central ESO/La Silla computer system which is reproduced in facsimile here and illustrated by Karen Saxby. For convenience of the reader, the central computer is indicated by a dash (–) and the observing astronomer with (:).

```
MESS   T=00004 IS ON CR04934 USING 00006 BLKS R=0047

0001   **** LOG DUMP FILE: 3.6/133/1984/JEDERMANN
0002   ****
0003   - GOOD EVENING AND WELCOME TO THE 3.6 M.
0004   - IS THIS YOUR FIRST RUN?
0005   : NO
0006   - WE SHALL CHECK THAT. WHAT IS YOUR NAME?
0007   : J. EDERMANN
0008   - INSTITUTE?
0009   : ASTROPHYSICAL INSTITUTE. ANYTOWN.
0010   - OK. YOU WERE HERE ON 123/1983. OK?
0011   : WELL .ER...
0012   - YOUR RECORD SAYS THAT YOU LOST 23.7 MIN DUE
0013        TO WRONG COORDINATES. DID YOU PREPARE
0014        YOUR OBSERVATIONS BETTER THIS TIME ?
0015   : PROMISE
0016   - OK. WE SHALL SEE... NOW GIVE YOUR ENTRY
0017   -    CODE NUMBER.
0018   : OPC/X2398.42859YZ
0019   - CHECKING. JUST A MOMENT.
0020        OK. ACCESS AUTHORIZED BY OPC. PROCEED.
0021        PRIME, CASS, OR COUDE FOCUS?
0022   : CASS.
0023   - OK. AVAILABLE. INSTRUMENT?
0024   : IDS ON B&C SPECTROGRAPH.
0025   - ARE YOU SURE YOU WANT THIS INSTRUMENT?
0026   : SURE.
0027   - ARE YOU REALLY SURE?
0028   : YES. DEFINITELY.
0029   - SORRY. I WOULD RECOMMEND TO TAKE THE
0030        D&E SPECTROGRAPH.
0031   : WHY?
0032   - NO ANSWER.
0033   : BUT WHY. I ASKED FOR THE OTHER!!
0034   - OK. TEMPORARY TROUBLES WITH B&C.
0035   : THEN CALL THE REPAIR UNIT.
0036   - REJECTED. THE CARIOCA GAME IS STILL ON.
0037   : I SEE. BRING IN THE OTHER SPECTROGRAPH.
0038   - OK. CASS MIRROR IN. D&E IN. IDS ON. OK.
0039   -    DONE. OBJECT?
0040   : NGC 8055.
0041   - COORDINATES 23:55:56.-78:23.5 (1984.4)
0042   - SORRY. IMPOSSIBLE OBJECT. REJECTED.
0043   : WHY?
0044   - ALREADY OBSERVED WITH THIS INSTRUMENT.
0045   : WHO DID THAT!!!!!
0046   - CLASSIFIED INFORMATION. NOT AVAILABLE.
0047   : OK. TAKE NGC 8056.
0048   - COORDINATES 23:56:55.-89:55:45 (1984.4)
0049   - SORRY. OUT OF RANGE (ZENITH DISTANCE 60:21W)
0050   : OH,PLEASE!!!!
0051   - OK. BUT ONLY THIS ONE!
0052   : PROMISE.
0053   - GO TO OBJECT. OPEN HATCH. MOVE DOME. AQUIRE
0054        OBJECT. SURROUNDING CONFIGURATION CHECKED
0055        OK. CENTER IN SLIT. AUTOGUIDER ON. START
0056        INTEGRATION. NOW. TIME 01:23:55.4 ET.
0057   - OBSERVATION STARTED. INSERT COMMENTS.
0058   : NGC8056. Z.D. IS COMPUTER RESPONSIBILITY.
0059   - THAT IS NOT FAIR. YOU ASKED ME.
0060   : OK. ASTRONOMERS RESPONSIBILITY.
0061   (PAUSE)
0062   - OBSERVATION STOP.
0063   : 'WHAT!! WHY?
0064   - ENOUGH PHOTONS RECEIVED. SIGNAL/NOISE = 7.89
0065   : BUT I WANT TO BE SURE.... PLEASE!!
0066   - REQUEST REJECTED. WASTE OF VALUABLE TELESCOPE
0067        TIME. NEXT OBJECT?
0068   : NGC 8056.
0069   - REJECTED. ALREADY OBSERVED WITH THIS
0070        CONFIGURATION.
0071   : WHO?
0072   - SORRY. CLASSIFIED INFORMATION.
0073   : OK. I GIVE UP. LET US GO TO THE NEXT OBJECT
0074        NGC 8057.
0075   - WHAT ABOUT THE NEW SUPERNOVA IN NGC 3333? I
0076        THINK THE OPC ALLOWED MINOR DEVIATIONS FROM
0077        YOUR ORIGINAL PROGRAMME?
0078   : YES. BUT...
0079   - I WOULD LIKE TO SEE WHAT IT LOOKS LIKE.
0080        IAU CIRCULAR 5123: TRANSFER DATA.
0081        MOVE TELESCOPE. MOVE DOME. ACQUIRE.
0082        OBSERVATION START. SPECTRAL DISPLAY ON.
```

```
: I AM GOING TO WRITE TO THE DIRECTOR GENERAL!!
(PAUSE)
: HEY, THAT IS NOT BAD! LOOK AT THOSE LINES!!
- FEXXIV AT V = 16789.45643 KMS
: WHAAW!!
- YOU SEE THAT I WAS RIGHT? PHOTOMETRY?
: SURE!
- INTEGRATION STOP. D&E OFF. PHOTOMETER ON.
    INTEGRATE. STOP. PICTURE?
: WELL, ER...
- OK. PHOTOMETER OFF. CASS MIRROR OUT. PRIME
    FOCUS MIRROR IN. TRIPLET ACTIVATE. LOAD
    CCD. INTEGRATE. TRANSFER ARRAY TO DISC.
    DISPLAY.
: WHERE IS THE SUPERNOVA? THERE ARE SO MANY
    STARS IN THAT PICTURE...
- HERE AT THE ARROW.
: OH, YEAH I SUPPOSE SO.
- WHICH JOURNAL?
: WHAT DO YOU MEAN??
- A&A, AP.J., A.J., M.N. OR ESO MESSENGER.
: I KNOW THOSE, BUT WHAT DO YOU MEAN?
- WHICH ONE DO YOU WANT FOR THE PUBLICATION?
: THAT IS NOT YOUR BUSINESS.
- SPECTRUM TRANSFORMED TO INTENSITY. WAVELENGTH
    SCALE CALIBRATED. NO. OF LINES IDENTIFIED: 87
    EQUIVALENT WIDTHS FOUND. LINE RATIOS COMPUTED.
    TEMPERATURE, PRESSURE, ABUNDANCIES OK.
    PHOTOMETRY OK. COLOURS TRANSFORMED TO STANDARD
    SYSTEM. 3 SATELLITE TRAILS AND 1 COMET CLEANED
    FROM THE DIRECT PICTURE. ABSTRACT, INTRODUCTION,
    OBSERVATIONS, DISCUSSION, CONCLUSION OK. ANY
    SPECIAL WISHES FOR TITLE AND ACKNOWLEDGEMENTS?
: HOW DO YOU DARE!!
- OK. TITLE: SUPERNOVA IN NGC 3333.
    ACKNOWLEDGEMENTS: ESO CENTRAL COMPUTER.
    TRANSMITTED TO: (A&A) COMPUTER.
: WHERE IS THE PANIC BUTTON?
- I AM NOT GOING TO TELL YOU.
    NEGATIVE REPLY FROM (A&A). STYLE TOO DRY.
    CALL EDIT-PROG. MORE POESY PLEASE. THANKS.
    TRANSMITTED TO: (MESSENGER) COMPUTER.
: WELL, PERHAPS, IN THIS CASE... PLEASE SHOW ME
    THE MANUSCRIPT, SO THAT I CA
- SORRY TO CUT IN, BUT PAPER NOW ACCEPTED BY
    (MESSENGER). CONGRATULATIONS. NEXT OBJECT?
: I##################################
(SUBSEQUENT DIALOGUE DELETED BY INTERNAL
 CENSORING PROGRAMME AFTER CROSS-REFERENCE
 WITH FILE "BADWORDS")
****
**** END OF LOG DUMP FILE 3.6/133/1984/JEDERMANN
```



R 136–Source of Excitation of the Tarantula Nebula

J. V. Feitzinger and Th. Schmidt-Kaler

Among the few extragalactic objects that can be seen with the naked eye, the LMC and its Tarantula Nebula (30 Doradus) are perhaps the most impressive. This nebula, a giant region of ionized hydrogen, has long attracted astronomers and has been extensively studied with a large variety of telescopes. Drs. Johannes Feitzinger and Theodor Schmidt-Kaler from the Astronomical Institute of the Ruhr University in Bochum, FRG, have recently obtained extremely interesting observations of the central stars in the Tarantula Nebula. It would appear that one of these objects, R136, could be the most massive single "star" that has yet been discovered.

The Centre of LMC?

One of the most fascinating objects in the Large Magellanic Cloud is the Tarantula Nebula (30 Doradus). It is a supermassive H II complex, unique in the whole LMC and in many respects similar to the supermassive H II regions in the centre of spiral galaxies. Like these, it is the starting point of the spiral filaments formed by the extremely young population of the Large Magellanic Cloud, and—again similar to many galactic nuclei—it shows evidence of mild activity.

These results, which we arrived at in 1975, have since been confirmed by many investigators, notably Elliott, Meaburn, Blades, Cantò and their co-workers. Contrary to nuclei of normal galaxies, however, the Tarantula Nebula is not situated in the centre of the galaxy. This may be linked to the activity of a galactic nucleus in a galaxy of comparatively small mass with a correspondingly flat, central po-

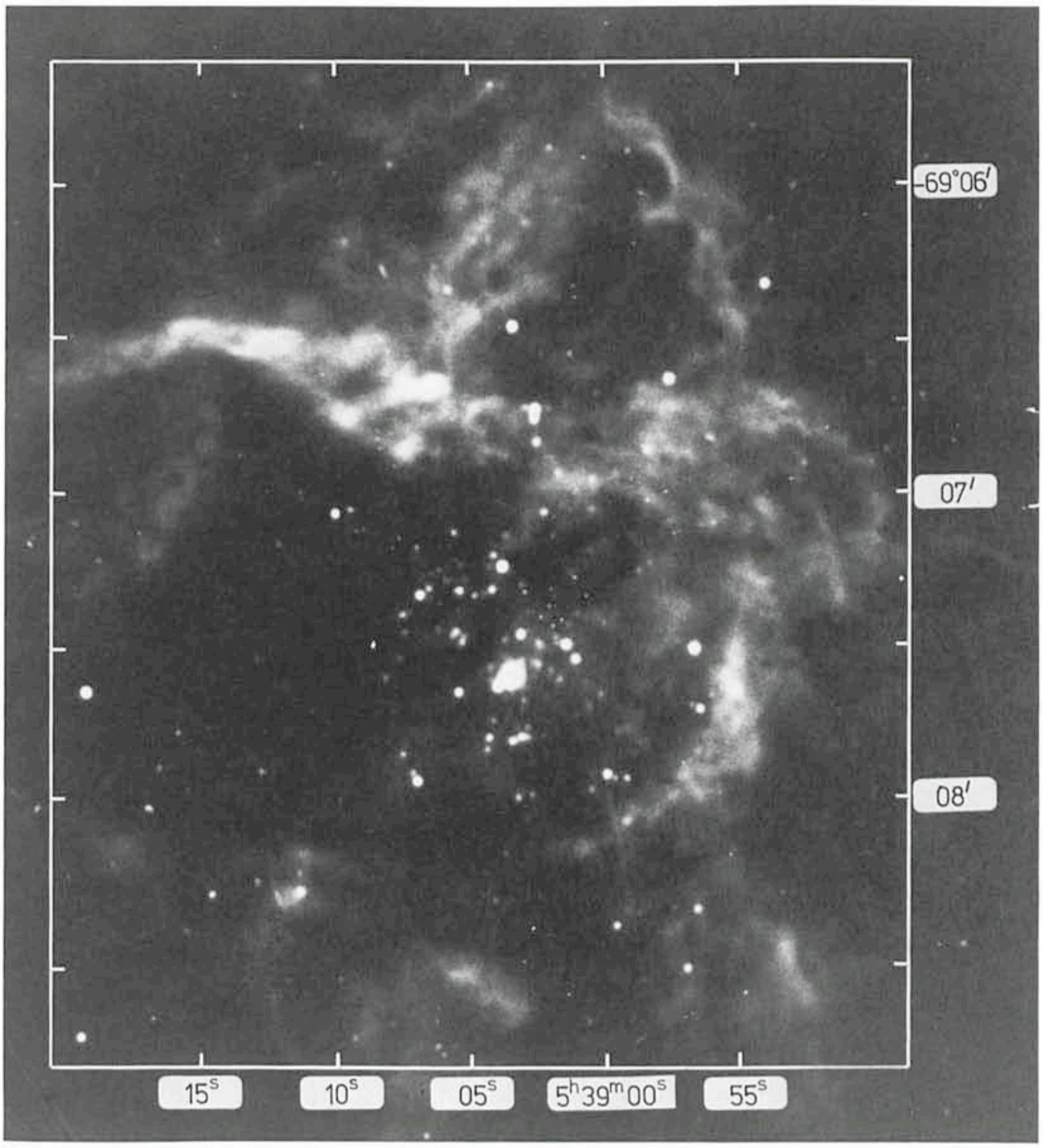


Fig. 1: *Hα photograph of 30 Doradus (3.6 m ESO telescope, 2 min exposure on 127-04, Δλ = 220 Å).*

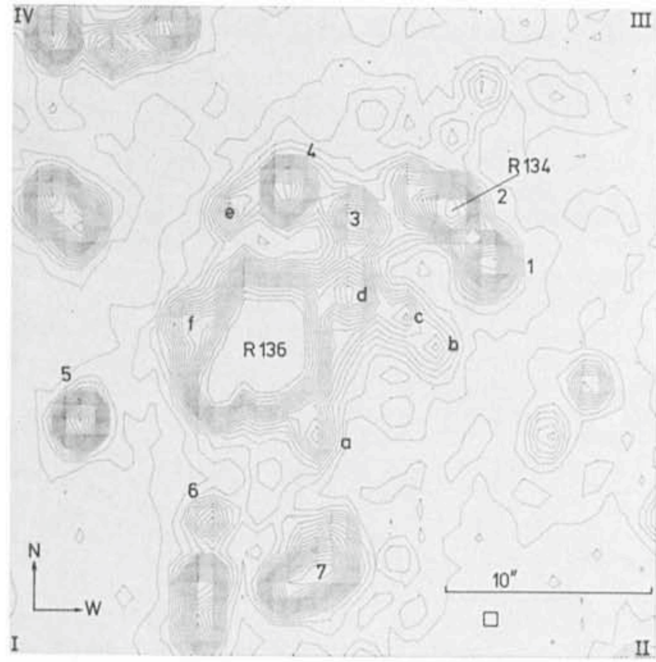


Fig. 2: *Isophote plot of the central stellar group (1–7: stars; a–f: condensation). The rectangle represents the photometer slot.*

tential well. In a massive galaxy with a deep potential well in its centre, even a very violent asymmetric explosion of the nucleus will not be able to move the nucleus considerably out of the centre. However, in a low-mass galaxy like the LMC such an explosion can lead to a large displacement of the nucleus from the geometrical centre and give rise to a basic asymmetry which subsequently determines the appearance of an irregular galaxy.

Such considerations make 30 Doradus even more interesting, apart from the fact that it is also by far the nearest supermassive H II region to be studied outside our own Galaxy.

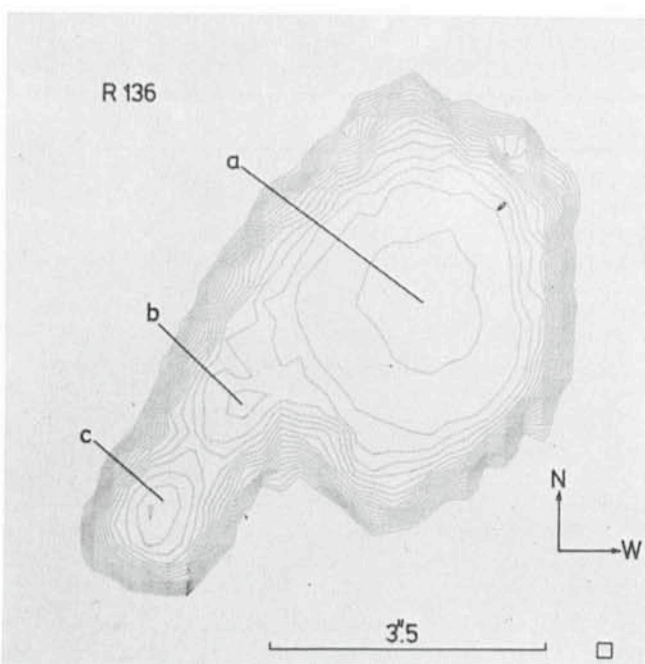


Fig. 3: *The object R 136 with the three components a, b, c.*

The first question is of course: what makes this enormous nebula shine? Feast, Fehrenbach, Azzopardi and Melnick discovered near its centre a dozen Wolf-Rayet stars, an O8 star and three B0.5 stars. Although these Wolf-Rayet stars are all considerably too luminous for their type, there is one outstanding object among them: Radcliffe No. 136. It is more than three magnitudes brighter than the next-brightest star there, it appears nebulous, and it shows emission-line profiles corresponding to an expansion velocity (projected on the plane) of 50 km/sec. Many ultraviolet absorption components at +270 ± 20 km/sec have also been seen in IUE satellite spectra, but they have been attributed—in an alternative interpretation—to a galactic halo around the whole LMC. If that is true, then these lines should also be present in the spectra of other LMC OB stars as well! Furthermore, R 136 shows CIV P Cygni profiles with an expansion velocity of 3,300 km/sec which is far beyond the range of all normal WR stars.

Observations at La Silla

A better understanding of R 136 will certainly give important clues to understand supermassive H II regions, galactic nuclei and their excitation mechanisms. So a series of short-exposure fine-grain plates was obtained at the Cassegrain focus of the Bochum 61 cm telescope and at the prime focus of the 3.6 m ESO telescope in UBVR and the near IR as well as Hα (cf. fig. 1); in addition, spectra were secured with the ESO 1.5 m telescope, and spectrophotometric scans were made with the Bochum telescope. The plates of best seeing have been treated by modern image analysis, i.e. they were scanned, and noise filtering, contrast enhancement, and background suppression were applied. The pixel-size was 0".8 x 0".8 = 0.2 pc x 2.2 pc, which is about half the smallest recognizable structure, cf. figs. 2, 3 and 4.

R 136 appears to be located in the centre of a slightly elliptical shell of gas of about 16 pc diameter which in turn is at the centre of the curved luminous arcs extending from the inner regions of the Tarantula nebula. The object itself is clearly resolved into three components of 4".3 or 1.1 pc distance. Component "a" with less than 1 pc diameter (fig. 3) contributes most to the whole luminosity and has by far the bluest colour U-V = –0.99, while component "c" has U-V = –0.44.

What is R 136?

R 136 has been interpreted as a very compact group of early O-type and Wolf-Rayet stars. In order to account for its luminosity, 50–100 such luminous stars ought to be packed together within a cluster of less than 1 pc diamter! That has never been observed. Furthermore, present ideas on star formation preclude the formation of more than a few very massive stars in one cluster. We therefore assume that R 136 is a single object.

We estimated its reddening from the colours observed and the interstellar extinction, using the normal interstellar extinction curve. We arrived at the tremendous luminosity M_v = –10.5. The temperature can be estimated at 50,000–55,000 K. This is just the temperature of HD 93250, the earliest O-type star known, which was recently determined by Kudritzki in Kiel, using non-LTE models (see *Messenger* No. 15, p. 26). The bolometric correction of such stars is not very well known; Morton's estimate is for WN5 and O5-8 between $-2^m.8$ and $-4^m.7$. Conservatively

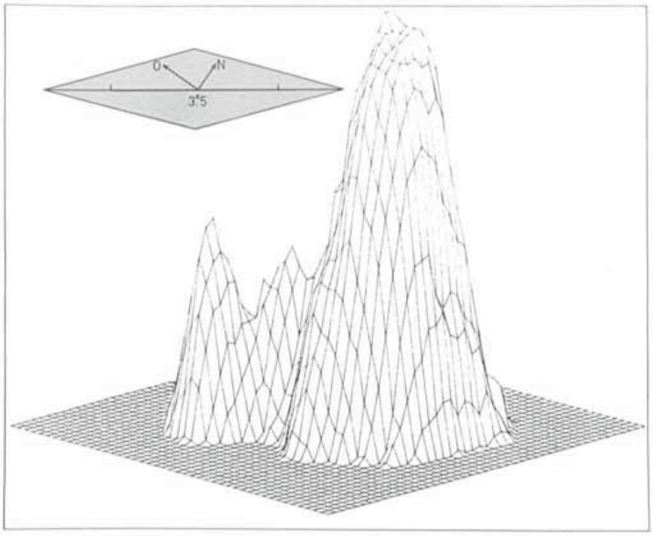


Fig. 4: *Three-dimensional representation of R136. The background intensity has been suppressed, the contrast enhanced.*

taking $-3^{m}.5$, we arrive at $L = 3 \times 10^7\ L_{\odot}$. The Lyman continuum flux of such an object is more than 5×10^{51} photons/sec. This yields an excitation parameter of 555, while the total value observed for the inner 1,000 pc of 30 Doradus by radio astronomers Churchwell and Walmsley is $U = 630\ pc/cm^2$. Indeed, together with the 15 remaining OB and WR stars, $U = 625\ pc/cm^2$ results.

What is the mass of this extremely luminous object? Certainly, its gravitation must be strong enough to prevent it from disruption by radiation pressure. The only important opacity source in such a very hot atmosphere is pure electron scattering. Thus we arrive at the Eddington limit at a mass between 200 and 1,000 $M_{\odot}$, depending on the hydrogen content. This is already in the mass range of supermassive objects—an intriguing idea!

Explaining the shell around R 136 as being due to a massive stellar wind we arrive at an age of that shell of 3×10^5 years—and that is just of the order of the life time of supermassive stars. The initial density turns out to $200\ cm^{-3}$, the total energy of the shell to 10^{51} ergs which might also indicate that a number of supernova explosions may have occurred.

The basic assumption of a single star has still to be confirmed. At our request Gerd Weigelt from the Institute of Applied Optics of the University of Erlangen obtained speckle photometry at the 3.6 m telescope (cf. *Messenger* No. 18, p. 24). He is presently reducing his data. We are most eagerly expecting his results!

Acknowledgements

Dr. Wolfhard Schlosser and graduate student Christoph Winkler contributed essential parts of the work described, which is to appear in *Astronomy & Astrophysics.* The methods of image processing used are described by Dr. Manfred Buchholz, Dr. Tobias Kreidl and Christoph Winkler on page 21.

NEWS AND NOTES

ASTEL—a FORTRAN Programme to Decipher IAU Telegrams

Astronomers have a long tradition of exchanging urgent information by telegram or, more recently, by telex. This concerns mainly new discoveries that must be followed up by other observers, e.g. moving objects like minor planets and comets, or variable sources, like supernovae, etc.

To keep the cost down, a special code has been devised which consists of five-digit groups, interspersed with information about the discoverer, the orbit computer, etc. This code is not difficult to interpret and many astronomers can read an astronomical telegram without having to consult the explanatory manual.

Nevertheless, it sometimes happens that this manual is temporarily misplaced or that somebody with little or no experience has to decipher a telegram. Moreover, to decode a long telegram takes a certain time. To facilitate this task, a FORTRAN programme has now been written, which allows the user to simply type in the telegram groups, one after another, and following the last, the programme will print out the entire text in clear language. The programme also checks the various control numbers in the telegram in order to discover possible transmission errors.

The programme has been implemented on the ESO HP computers at La Silla and in Geneva. With the possible exception of the input/output format, it should be easy to install it in any computer that can compile FORTRAN programmes. Xerox copies of the programme (the source file) are available at request from R. West, ESO c/o CERN, CH-1211 Geneva 23, Switzerland.

ALGUNOS RESUMENES

Bienvenido a La Silla!

Un «nuevo» telescopio se encuentra operando en La Silla desde fines de marzo de 1979. El telescopio fotométrico de 90 cm de la Estación Austral de Leiden en Sudáfrica fue ya instalado en el año 1958, y se decidió su cambio a La Silla debido a las deterioradas condiciones de observación existentes allá, causadas principalmente por la polución proveniente de las cercanas ciudades de Pretoria y Johannesburgo. El instrumento se encuentra actualmente instalado en el antiguo edificio del telescopio de 1 m, conocido también como cúpula del «Chilimap». Tal como se había esperado está trabajando perfectamente en su nuevo ambiente y de él se espera que alivie en algo la gran demanda que existe para observar con el telescopio fotométrico de 1 m de ESO.

La Silla en el cielo ...

En su edición del 1° de diciembre de 1979 el «Minor Planet and Comet Circular» hace referencia a un nuevo planeta menor recientemente descubierto, el 1976 UH, enumerado (2187) en la página 5036, y nombrado LA SILLA en la página 5039.

La dedicación dice: «Nombrado por el cerro situado en el Desierto de Atacama en cuya cima se encuentra el observatorio Europeo Austral». Es interesante notar que el tamaño del nuevo planeta no difiere mucho del cerro La Silla, y – en vista del permanente aumento del riesgo de la polución (luminosa y atmosférica) que amenaza a muchos observatorios (sin embargo por cierto no a los establecimientos de ESO actualmente) – uno se pregunta si no se estará presenciando un ejemplo extremo de planeamiento a muy largo plazo?!

ESO, the European Southern Observatory, was created in 1962 to . . . establish and operate an astronomical observatory in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organizing collaboration in astronomy . . . It is supported by six countries: Belgium, Denmark, France, the Federal Republic of Germany, the Netherlands and Sweden. It now operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where ten telescopes with apertures up to 3.6 m are presently in operation. The astronomical observations on La Silla are carried out by visiting astronomers—mainly from the member countries—and, to some extent, by ESO staff astronomers, often in collaboration with the former.

The ESO Headquarters in Europe will be located in Garching, near Munich, where in 1980 all European activities will be centralized. The Office of the Director-General (mainly the ESO Administration) is already in Garching, whereas the Scientific-Technical Group is still in Geneva, at CERN (European Organization for Nuclear Research), which since 1970 has been the host Organization of ESO's 3.6-m Telescope Project Division.

ESO has about 120 international staff members in Europe and Chile and about 150 local staff members in Santiago and on La Silla. In addition, there are a number of fellows and scientific associates.

The ESO MESSENGER is published in English four times a year: in March, June, September and December. It is distributed free to ESO employees and others interested in astronomy.

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Editor: Richard M. West
Technical editor: Kurt Kjär

EUROPEAN
SOUTHERN OBSERVATORY
Schleißheimer Straße 17
D-8046 Garching b. München
Fed. Rep. of Germany
Tel. (089) 3204041-45
Telex 05215915 eso d

Printed by Universitätsdruckerei
Dr. C. Wolf & Sohn
Heidemannstraße 166
8000 München 45
Fed. Rep. of Germany

Un techo para la ESO

El día 8 de noviembre de 1979 marcó una etapa más en la historia de ESO. El nuevo edificio en Garching, al norte de Munich, que será la sede principal de ESO, fue escenario de una alegre celebración con motivo de sus tijerales.

Estuvieron presentes la mayoría de las personas que participaron en el planeamiento y en la construcción, desde sus arquitectos, ingenieros y obreros a algunos miembros del personal de ESO, encabezados por su Director General. Una serie de elegantes discursos dieron el marco adecuado al evento.

Actualmente se está terminando la parte exterior del edificio y muy pronto el concreto se encontrará completamente en su lugar. Se ha comenzado con las instalaciones interiores y se presume que todo estará terminado para recibir al personal de ESO hacia fines del verano de 1980.

Algunas impresiones fotográficas se encuentran en las páginas 13-15.

Estrellas de neutrones

El Dr. Ed Zuiderwijk, del grupo científico de ESO en Ginebra, se encuentra haciendo estudios teoréticos y de observación de estrellas de neutrones, las que para los astrónomos cuentan entre los objetos más fascinantes en el cielo.

Las estrellas de neutrones se originan de explosiones de supernovae, donde el centro estelar se derrumba bajo el efecto de su propia gravedad. Su masa es comparable a la de nuestro sol, pero su diámetro es de tan sólo 15 kilómetros. Por lo tanto, la materia de estas estrellas es extremadamente densa y un milímetro cúbico (que corresponde aproximadamente al tamaño de la cabeza de un alfiler) pesa un millón de toneladas.

Sin embargo, aun muchas preguntas deberán ser contestadas en relación a estos objetos, y se espera que el programa de observación a largo plazo, que se está llevando a efecto en La Silla, ayude a contestar algunas de ellas.

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