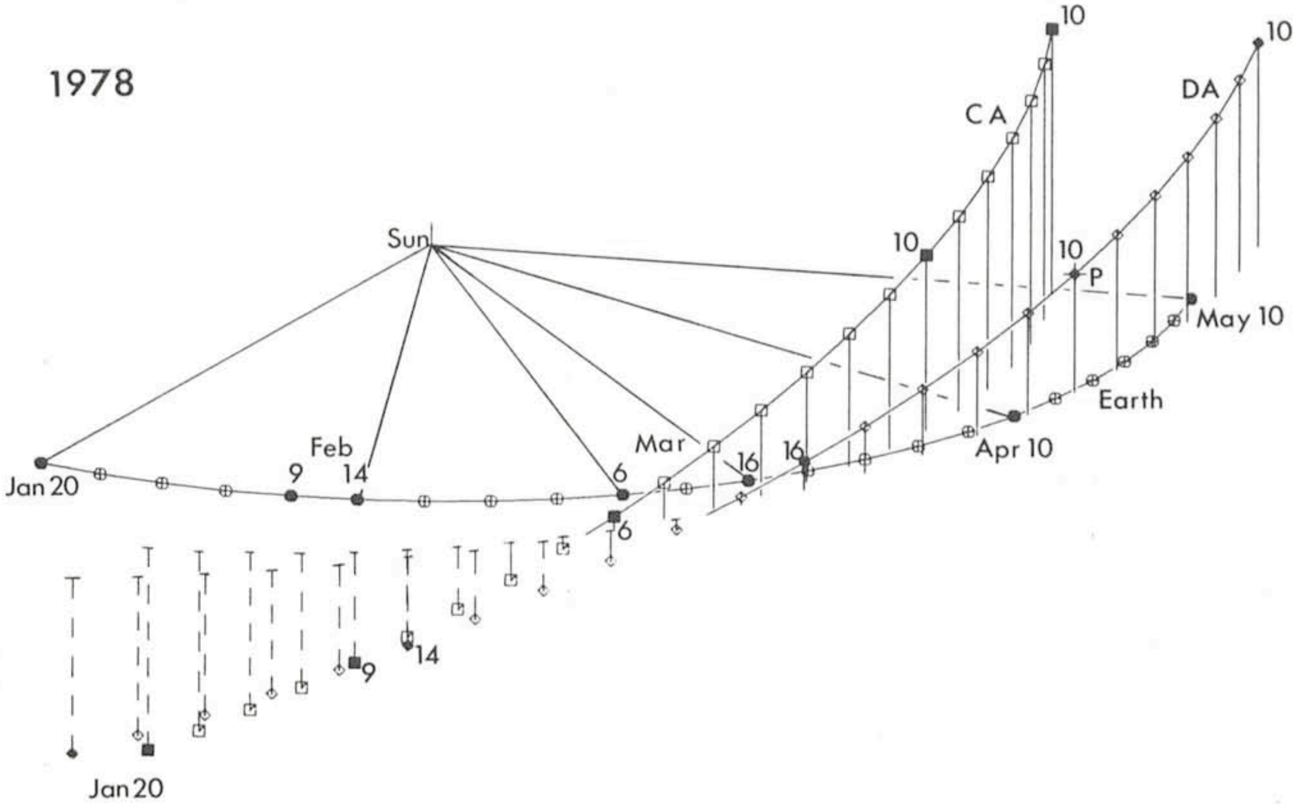
No. 13—June 1978

This issue of the *Messenger* focusses on the recent discovery of two Earth-approaching minor planets. Both were found with the ESO Schmidt telescope on La Silla by Dr. Hans-Emil Schuster. Working in close collaboration with Dr. B. Marsden of the Smithsonian Observatory in the USA, it was possible to establish the orbits *before* the closest approaches in March 1978. This enabled other observers to study the tiny planets and to learn more about their physical properties.

Although moving in very different orbits, 1978 CA and DA came within 3.8 million kilometres of each other on February 17, 1978.



The fly-by of 1978 CA and 1978 DA early 1978. The orbits of the Earth and the two minor planets are shown during a period of about four months, centered on the dates of closest approaches in March. The planets are marked at five-day intervals. Those parts of the orbits which are above the Ecliptic (plane of the Earth's orbit) are fully drawn. In order to better visualize the three-dimensional positions, vertical lines connecting the minor planets to the Ecliptic have been traced. 1978 CA was discovered on February 8 and came within 19 million kilometres on March 8; 1978 DA was discovered on February 17 and was only 13 million kilometres from the Earth on March 15. Note also the very close encounter between the two planets on February 17.

The Close Encounter with 1978 CA and 1978 DA

It was a fine night on La Silla. Astronomers were working with all of the ESO telescopes, scrutinizing the southern skies with spectrographs and photometers and the big Schmidt was busy, taking deep photographs.

It was the night between February 7 and 8. After midnight, ESO astronomer Hans-Emil Schuster put a red-sensitive plate in the Schmidt telescope and settled down to guide during the 90-minute exposure time. The field was in the southern part of the constellation of Hydra (The Water Serpent) and it contained a prominent cluster of galaxies. Later in the morning, the plate was developed and Hans Schuster had a quick check of the image quality, before the plate was to be sent on to the "visiting" astronomer who had asked for it.

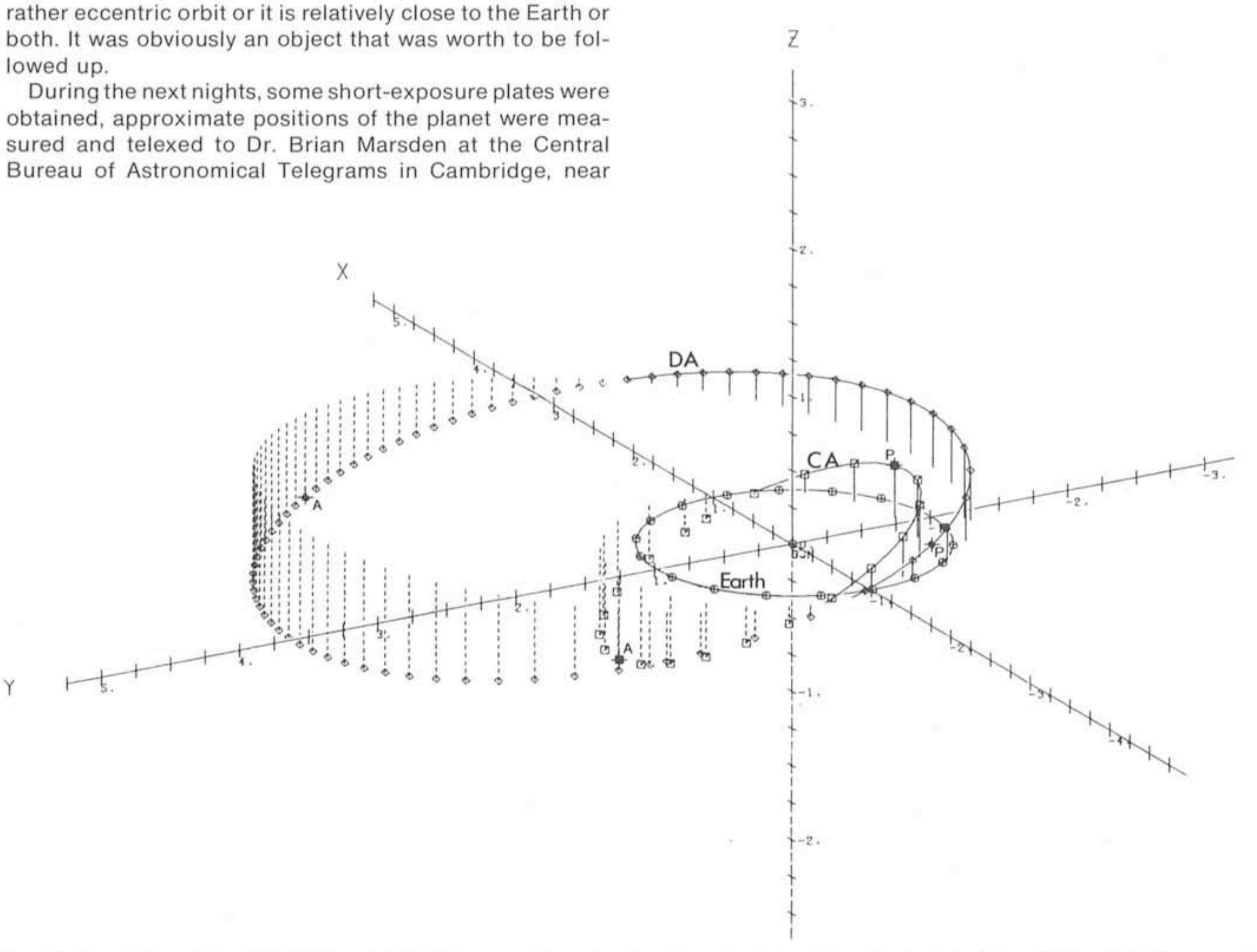
Down in the lower right corner, near the 6^m star HR 4130, he noticed a comparatively faint trail of a minor planet. During the $1^1/_2$-hour exposure, the small planet had moved about 1.8 millimetre towards the north. Trails of this length are not infrequent on long-exposure plates, but two facts caught the attention of the ESO astronomer; the distance from the Ecliptic (about 30°) and the direction of motion, almost due north.

This normally means that either the planet is moving in a rather eccentric orbit or it is relatively close to the Earth or both. It was obviously an object that was worth to be followed up.

During the next nights, some short-exposure plates were obtained, approximate positions of the planet were measured and telexed to Dr. Brian Marsden at the Central Bureau of Astronomical Telegrams in Cambridge, near Boston, Massachusetts. Dr. Marsden calculated a preliminary orbit and could immediately confirm the suspicion that the new minor planet was rather close to the Earth. Improved orbital data later showed the distance to have been 42 million kilometres on February 8. The asteroid was given the name 1978 CA and was evidently rapidly approaching the Earth.

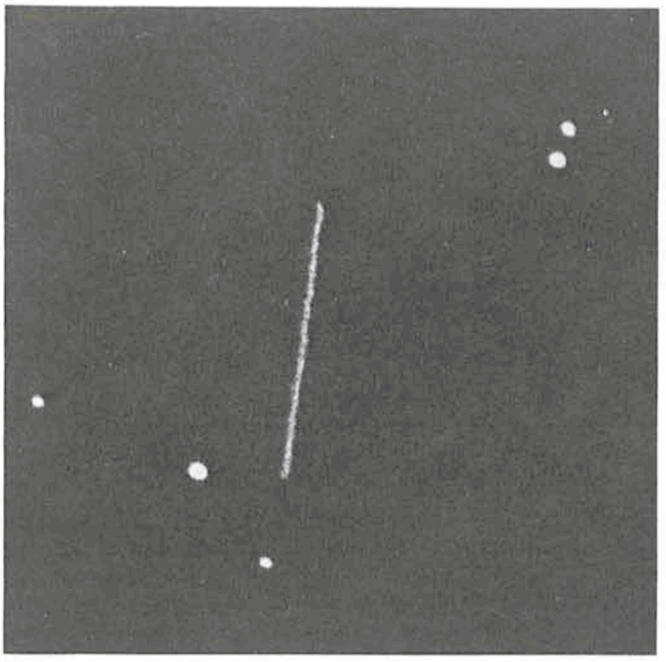
Further plates were obtained during the new moon period and the planet was followed towards north while its daily motion was rapidly increasing. On February 17, due to a minor mistake, the plate was off-set about two degrees to the east, so that 1978 CA was rather close to the *western* edge. Going over the plate, Hans Schuster noticed another very long trail, only 2 mm from the *eastern* edge! There was little doubt that this was yet another Earth-approaching planet, running due east. More plates were taken and a week later Dr. Marsden could confirm that 1978 DA (as the second planet was called) would also come rather close to the Earth.

All available plates were sent from La Silla to ESO/Geneva and were measured accurately on the ESO S-3000 two-coordinate measuring machine. Thanks to the



A projection of the orbits of 1978 CA and 1978 DA, as seen from the direction of ecliptical (longitude, latitude) = (150°, +20°). The vernal equinox is in the direction of the X-axis and the Y-axis is perpendicular to the X-axis in the ecliptical plane. The Z-axis points towards the ecliptical north-pole.

The planets are indicated at 20-day intervals. The motions are slower at the aphelia (A) than at the perihelia (P)—in particular for 1978 DA. Only the Earth is shown among the major planets to avoid overcrowding the figure, which was drawn by a Calcomp plotter attached to the ESO/HP system in Geneva. The units are Astronomical Units (A.U.).



1978 CA: Trail on a 15-min exposure with the ESO Schmidt telescope on March 1, 1978.

1978 DA: Trail on a 15-min exposure with the ESO Schmidt telescope on March 8, 1978.

accuracy of this machine (of the order of one micron), the new Perth catalogue that furnished the astrometric standard stars and an improved computer programme, it is now possible to measure about 15 plates per day. The positions of 1978 CA and DA were telexed to Dr. Marsden, who computed the improved orbits the same day.

From then on, other astronomers took over. The two asteroids were moving rapidly and positions were obtained in Australia, Japan and the USA. Other observers measured the objects photoelectrically and radiometrically near their closest approaches on March 8 and 15, respectively. More details about these important observations are given by J. and A. Surdej and J. Degewij in the following articles.

The Orbits

1978 CA is an Earth-crossing minor planet and therefore belongs to the noble family of "Apollos" of which 21 are now known. It follows an orbit slightly larger than that of the Earth with a period of 435 days. The orbit is somewhat inclined to the Ecliptic (26°) and close encounters with the Earth may take place in March and September. Since the period of 1978 CA is close to 6/5 of one year, five orbital revolutions of 1978 CA will take six years and we may therefore expect to have another fly-by in 1984. However, whereas the minimum distance in 1978 was about 19 million kilometres, that in 1984 will be around 28 million kilometres, according to Dr. Marsden.

1978 DA flies in an orbit quite different from that of CA. Since it does not cross the Earth's orbit at 1 A.U.—its perihel is at 1.024 A.U.—it is called an "Amor" planet (a Mars-crosser). Of these 13 are now known. The orbit is rather elongated (the eccentricity is 0.588) and the period is 1,433 days, almost 4 years. We may therefore expect to see 1978 DA again in 1982. Actually, the orbit of 1978 DA is believed to change rapidly, and it is very probable that it was recently (or will soon become) an "Apollo" planet like 1978 CA.

Photometric Observations of 1978 CA and 1978 DA

Jean and Anna Surdej

By modern custom, as soon as a new minor planet has been discovered, it is given a provisional number including the year of its discovery followed by two letters. The first letter indicates the number of the fortnight (A = 1, B = 2, . . .), counted since the beginning of the year during which the first observation was made. The second letter (A = 1st, B = 2nd, . . .) is an incremental number ordering all the observations of minor planets within that fortnight. Since the first new asteroid was found on February 8, it was designated 1978 CA. The second asteroid, discovered on February 17, was named 1978 DA.

Until now, the origin as well as the physical and chemical properties of "Apollo" and "Amor" type asteroids are poorly known. Could, for instance, 1978 CA be the rest of an inactive comet nucleus? Furthermore, it is also not known whether "Apollo" and "Amor" type asteroids resemble certain classes of meteorites and whether they may be associated with the numerous minor planets circling the Sun between the orbits of Mars and Jupiter.

The Observations

Two nights at the ESO 1 m telescope were allotted to us on March 1 and 2, 1978 for UBV photometric observations of 1978 CA and 1978 DA.

On March 1, when 1978 CA (see the photo above left) was crossing the sky at such a high speed rate as 3°.5 per

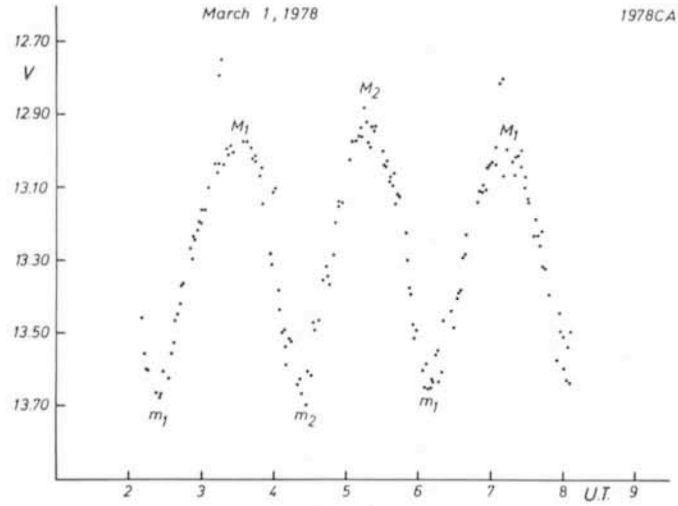


Fig. 1.

day, a complete, periodic light curve could be recorded within 3 hours and 45 minutes. Figure 1 shows these photometric observations in the equivalent Johnson V filter. Such a smooth light curve, nearly symmetric, and with large variations ($\Delta V \simeq 0.8$ mag) is easily interpreted as due to the scatter of sunlight by a spinning, elongated object (rock, . . .) around a fixed axis in space (see below!). Roughly, the light minima (m_1, m_2) reflect the two smallest projected areas of the tumbling asteroid, while the light maxima (M_1, M_2) correspond to the two largest areas as seen by a terrestrial observer. The extremely short period of rotation, $P \simeq 3^h 45^m$, places 1978 CA as the third fastest rotator among all known solar objects. "How short are the nights and days!" would have exclaimed Saint-Exupéry's "Le Petit Prince".

The colour indexes of 1978 CA appear redder than one would expect from a Sun-like star, (B-V) $\simeq$ 0.90 and (U-B) $\simeq$ 0.48. The reader will notice the three humps located at around 3.2^h, 4^h and 7^h U.T. in the light curve of 1978 CA. These are associated with the frequent encounters of field stars very close to the trajectory of 1978 CA. As a matter of fact, one encounter even turned out to be a real occultation!

Observations performed on March 2, 1978 resulted in the light curve of 1978 DA (see Figure 2). Because some time was lost when identifying this fast-moving asteroid and because 1978 DA turns around its axis much slower than 1978 CA, we were not able to monitor the light changes

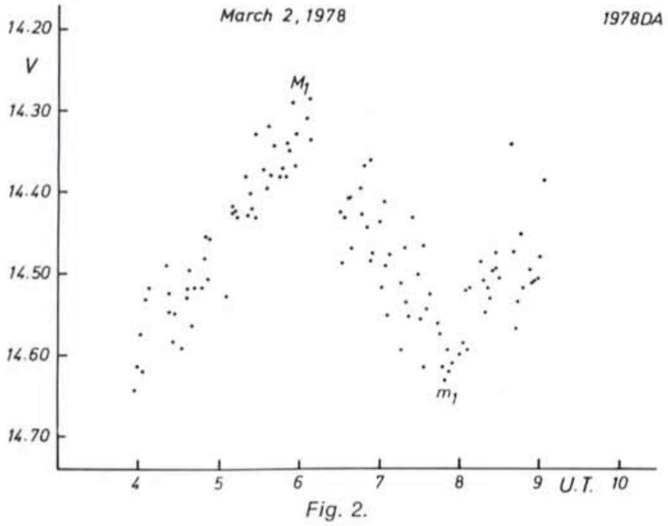


Fig. 2.

during one full cycle of rotation. The colour indexes were found to be B-V = 0.83 and U-B = 0.41.

Asteroid Models

Finally, we shall present below a rapid view on a model which allows an explanation of the light curve of 1978 CA. Simulating the rotation of an asteroid by a three-axis ellipsoidal model and describing the scattering properties of a small surface element by an adequate relation (Hapke-Irvine's), Figure 3 presents several light curves computed at different positions of an asteroid along a hypothetical trajectory. The ellipsoid was turned around its shortest axis and, for the given example, the adopted axis ratio a:b:c was taken to be 5:3:1. Furthermore, all light changes shown in Figure 3 neglect the distance effects (the geocentric Δ and heliocentric r distances were taken as 1 A.U.

Generally, the shape of a light curve will depend not only on the adopted geometrical form of the asteroid, the reflection law of sunlight, etc., but also on the configuration of the observations. For instance, the light curve labelled No. 1 in Figure 3 is that reflected by the spinning ellipsoid as it is viewed pole-on rather than when the pole axis is appreciably inclined to the line of sight (light curves Nos. 9, 10 and 11).

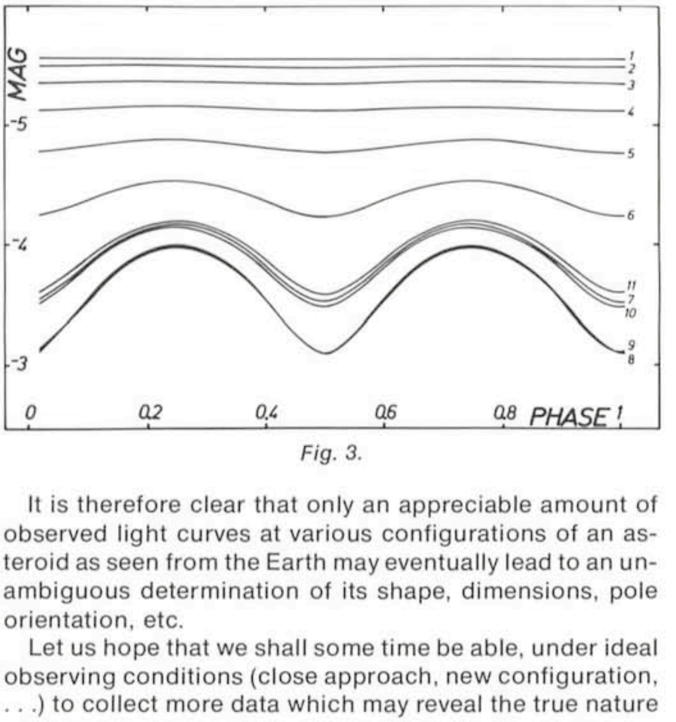


Fig. 3.

It is therefore clear that only an appreciable amount of observed light curves at various configurations of an asteroid as seen from the Earth may eventually lead to an unambiguous determination of its shape, dimensions, pole orientation, etc.

Let us hope that we shall some time be able, under ideal observing conditions (close approach, new configuration, . . .) to collect more data which may reveal the true nature of these very unusual asteroids!

List of Preprints Published at ESO Scientific Group

January – April 1978

19. G. CONTOPOULOS: Higher order resonances in dynamical systems. January 1978. Submitted to: *Celestial Mechanics.*
20. A. C. DANKS, J. W. HARTSUIKER: uvbyR Surface photometry of the 30 Doradus region II. February 1978. Submitted to: *Astronomy and Astrophysics, Suppl. Series.*
21. J. BREYSACHER, B. E. WESTERLUND: Wolf-Rayet stars in the Small Magellanic Cloud. March 1978. Submitted to: *Astronomy and Astrophysics.*
22. I. J. DANZIGER, P. G. MURDIN, D. H. CLARK, S. D'ODORICO: Spectra of supernova remnants in M33. March 1978. Submitted to: *Monthly Notices of the Royal Astronomical Society.*

The Sizes of 1978 CA and 1978 DA

Johan Degewij
Lunar and Planetary Laboratory, University of Arizona

While in the midst of making the reductions of the data obtained for 1978 CA and DA, it is hardly possible to give a coherent story about the physical parameters for these two km-size bodies. This short note gives a description of the observational work done with the instruments of the Lunar and Planetary Laboratory.

Jonathan Gradie obtained the first hour of observations at the 154 cm telescope in the Catalina Mountains on 7 March UT with the photopolarimeter MINIPOL (Frecker and Serkowski, 1976). With the polarization data no insight was yet possible into an albedo value, because the measurements were done close to the so-called inversion angle, the phase angle where the polarization vector changes from a negative orientation (in the plane of scattering) to a positive orientation (perpendicular to the plane of scattering).

The following night Marcia and Larry Lebofsky measured the flux of both objects at 10 microns with the 71 cm telescope on Mount Lemmon, while I worked several kilometres away with the 154 cm reflector and MINIPOL, obtaining a light curve in the Johnson colours *V* (Fig. 1) and *I*, together with polarization data for CA and *UBV* colours for both objects. By combining the 10 micron fluxes and *V* magnitudes it is possible, with a proper radiative model (Lebofsky *et al.*, 1978), to obtain albedos and mean diameters of 0.068 ± 0.006 and 1.86 ± 0.04 km for CA, and 0.17 ± 0.03 and 0.90 ± 0.05 km for DA. Both objects showed typical *S*-type *UBV* colours.

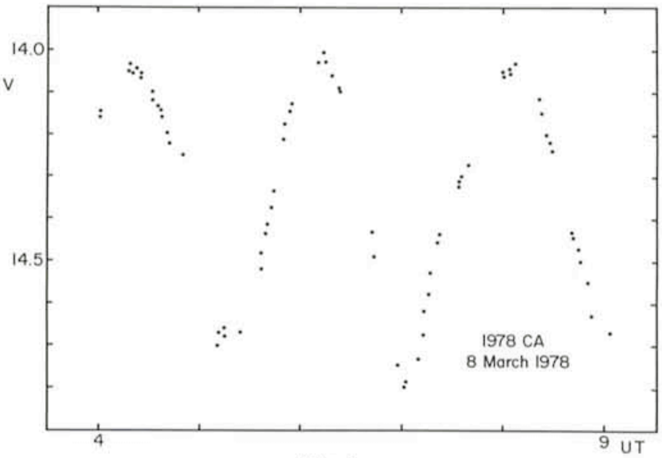


Fig. 1.

It was immediately clear that CA showed a very low albedo for an asteroid with reddish colours, and more polarization measurements were done during the third and fourth nights with the 154 cm telescope to confirm the radiometric albedo using the relation between polarization and phase angle. In addition, colours in the red part of the spectrum were measured to get a more detailed insight into its reflection spectrum.

By combining the pieces of light curves obtained during the four nights, we are able to derive a rotation period of $3^h 45^m 38^s \pm 3$ seconds. Figure 2 shows the total averaged light curve, but without the data points.

Recently Jean Surdej was kind enough to send us his data, and Ron Taylor will attempt to see whether it is possible to get an insight into the orientation of the pole and the sense of rotation.

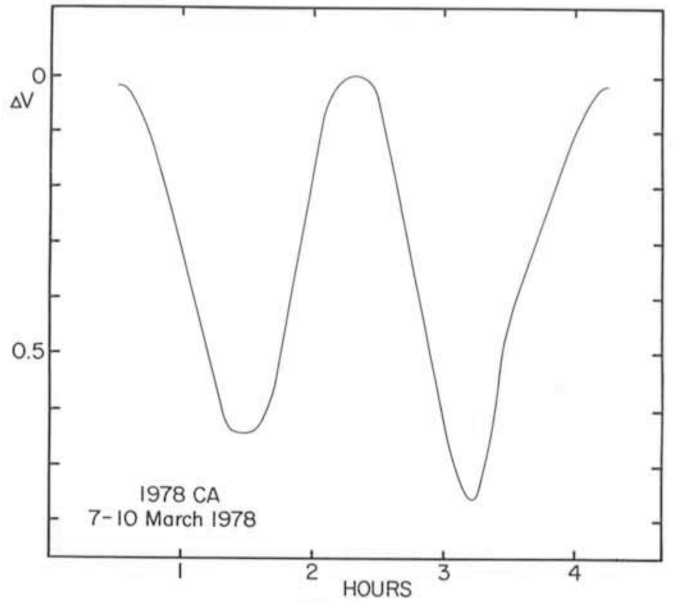


Fig. 2.

We also obtained a short stretch of light curve for 1978 DA (Fig. 3), but very little can be said about a rotation period.

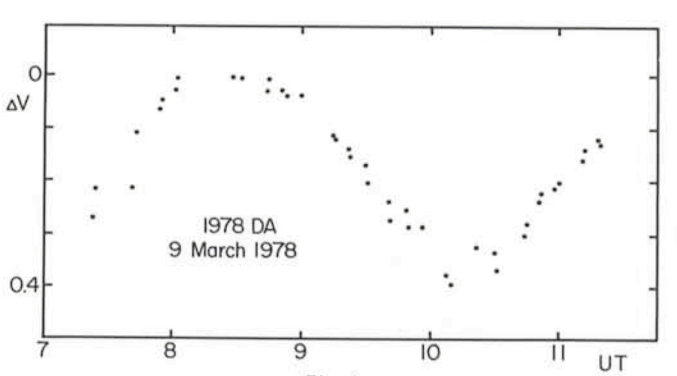


Fig. 3.

We are very happy with the existence of such an active group at ESO, observing the km-size bodies in the solar system. With fast communication, observers with suitable instruments may unravel the mysteries of the km-size bodies and their possible interrelation with cometary nuclei.

References

Frecker, J. E. and Serkowski, K. (1976). *Appl. Opt.* **15,** 605.
Lebofsky, L. A., Veeder, G. J., Lebofsky, M. J. and Matson, D. L. (1978). Accepted for publication in *Icarus*.

Novae Observed at La Silla

H. W. Duerbeck

Few astronomical events receive as much attention by amateur astronomers as the appearance of new stars in the sky, i.e. nova outbursts. Many novae are discovered by persistent sky watchers far from the large observatories and it is only somewhat later that these spectacular astronomical events come to the notice of professional astronomers through the telegram service of the International Astronomical Union.

Dr. Hilmar W. Duerbeck of the Hoher List Observatorium near Bonn in the Federal Republic of Germany has observed several novae from La Silla.

Certainly no astronomer will provoke the complete rejection of his application for observing time by proposing that he would like to observe a nova outburst. On the other hand, an observer may hopefully change his original programme somewhat when such an unpredictable event takes place.

During fairly long observing runs in 1975 and 1976 the writer has experienced the feverish activity when an IAU telegram with the news of a nova outburst arrives. In 1975, Professor Walter (Tübingen) entered the astro-office on La Silla one afternoon with a Xerox copy of such a telegram and said "we must observe this", and started to prepare finding-charts for the X-ray nova (= V616) Monocerotis. The UBV observations that were made with the ESO 50 cm telescope in the following weeks gave the first indication of a brightness variation with a period of 4 (or 8) days, obviously caused by the orbital motion of an exotic close binary star (*Astr. Astrophys.* **48,** 141 (1976)). This periodicity was later confirmed through X-ray data and photoelectric observations made from La Silla about half a year later (Chevalier, Ilovaisky and Mauder, IAU Circ. 2957 (1976)).

Nova Mon 1975 was unique among the novae known at that time, and it is certainly not a "classical" nova with an expanding shell. The discovery of a very similar object only two years later (Nova Ophiuchi 1977, H1705–25) indicates that a new class of variable stars, "X-ray novae", might be established in the near future.

In the autumn of 1976, the discovery of a nova in the constellation Vulpecula was reported. It was not a favourable object, in the evening sky, for La Silla. Nevertheless, a fairly long series of UBV observations could be obtained with the ESO 50 cm telescope. Nova NQ Vul exhibited a rather irregular light curve during outburst. It initiated a general study of the behaviour of novae in the two-colour diagram, from the early stages, when the emission lines are weak

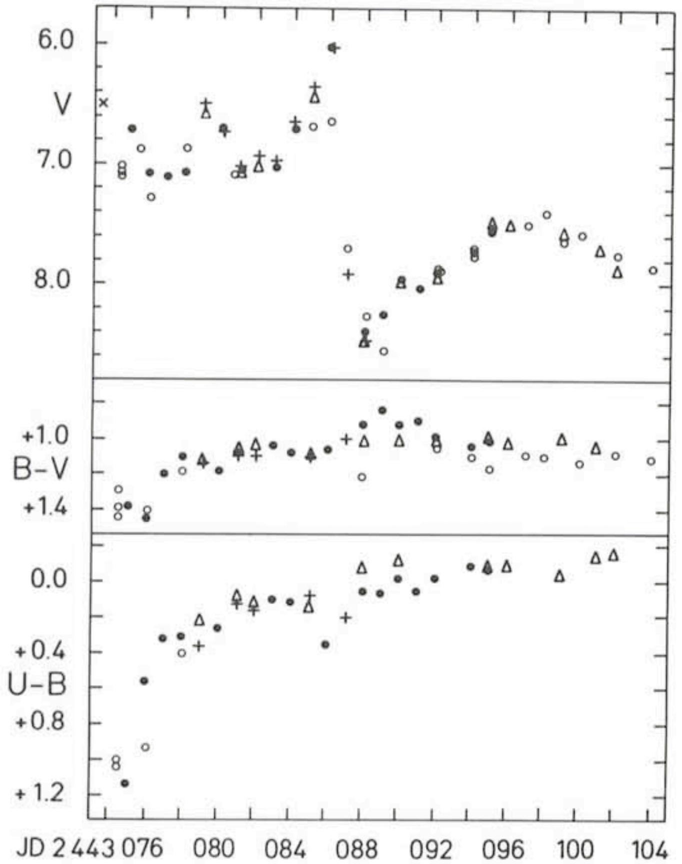


Fig. 1. — *UBV light curves of nova NQ Vul (1976). The large dots are measurements obtained with the ESO 50 cm telescope.*

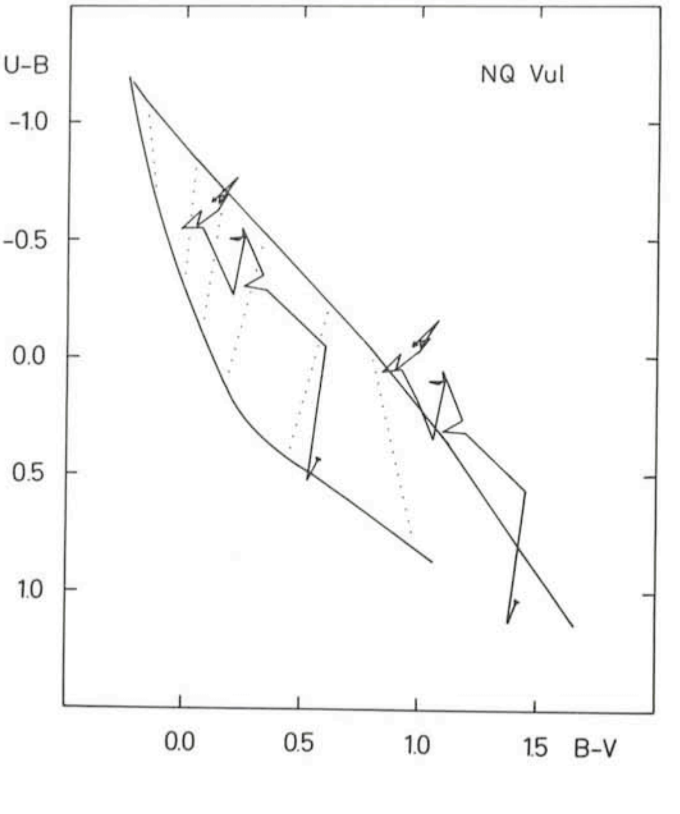


Fig. 2. — *The path of NQ Vul in the two-colour diagram (reddened and unreddened). The supergiant and black-body sequences are shown, dotted lines are isothermal lines. In the maxima of the light curve, the nova approaches the supergiant sequence.*

and the continuum energy distribution shows still some resemblance with that of supergiant stars, to the late stages, when the spectrum is dominated by emission lines and the photoelectric observations are difficult to interprete. It was found that—in contrast to some earlier views—broad-band photoelectric observations can be very useful. The path of a nova in the two-colour diagram is well suited for classifying the type of nova outburst (fast–medium–slow), it gives an information about the actual stage of the outburst (pre-maximum–maximum–later stages)—especially important when spectroscopic observations are missing—and it even permits to determine the physical characteristics of the outburst (radii, temperatures . . .), the total luminosity, and the amount of matter ejected during the outburst.

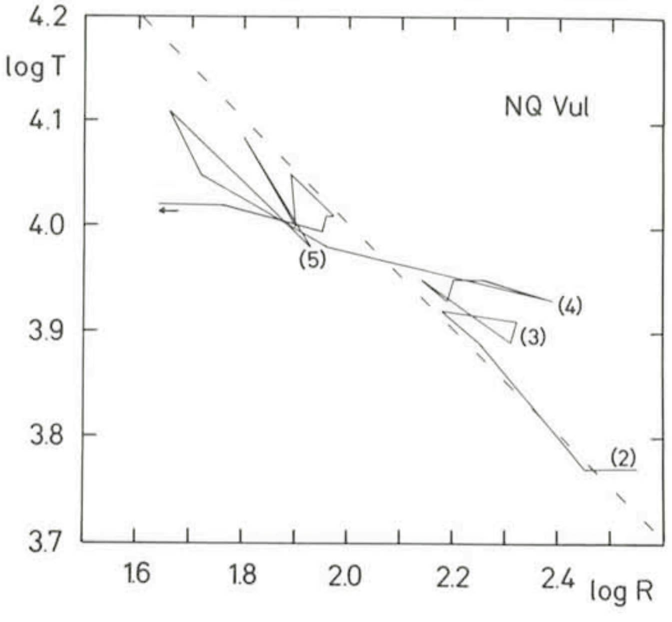


Fig. 3. — *log T – log R diagram of NQ Vul. The 45° slope corresponds to constant luminosity. The numbers designate various maxima in the light curve of the nova.*

As an interesting detail the variation of the radius and the temperature of NQ Vul is shown for different times in the log T–log R diagram. Scales are arranged in such a way that a 45° slope corresponds to constant luminosity. For NQ Vul, the luminosity seems to have remained constant within 50 per cent for a time of 30 days, while the visual brightness changed by a factor of 4. Similar results have been derived for nova FH Serpentis through observations in the extreme UV (by satellites) and IR observations, while this result for nova NQ Vul is based on UBV photometry only. Results will be given in a series of forthcoming articles in *Astr. Astrophys.*, by W. Seitter and the writer.

The most fascinating event was, of course, the spectacular appearance of nova (=V1500) Cygni in late August 1975. An IAU telegram that arrived in the afternoon of August 29 was not communicated to the Visiting Astronomers because of the "inobservability" of the nova from La Silla. It so happened that a V.A., who directed his steps from a dome to the hotel, gazing at the northern constellations with some feeling of homesickness, suddenly ran back to the dome, looking for a star map and saying to his fellow observer: "Either I am crazy, or there is a nova in Cygnus"; and after some minutes, all the domes were alarmed by phone and turned their contents to this unusual position in the sky over La Silla (except one telescope whose control computer typed "zenith distance!" and refused to cooperate). Dr. Thé (Amsterdam) observed at the Bochum telescope; his VRI observations of nova Cyg were published in IBVS No. 1089. Dr. Wamsteker (ESO) observed the nova at infrared wavelengths with the 1 m telescope *(Astr. Astrophys.,* in press), and Dr. Wolf (ESO/Heidelberg) and the writer obtained a series of coudé spectra with the 1.52 m telescope, which showed clearly the appearance of the diffuse enhanced spectrum, which was of short duration and of extreme weakness in nova Cyg *(Astr. Astrophys. Suppl. Ser.* **29,** 297 (1977)). The observations from La Silla were the first ones which gave this evidence. Confirmation from other observers came only after a second inspection of their data.

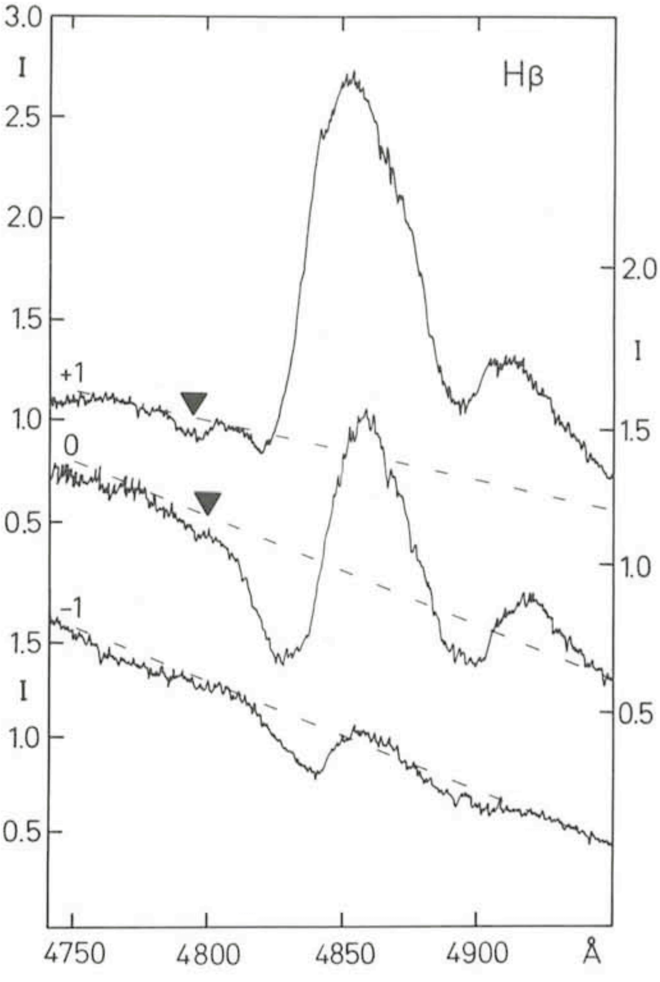


Fig. 4. — *The evolution of the Hβ line in nova V 1500 Cyg (1975), derived from ESO 1.52 m coudé spectrograms. At pre-maximum (day −1), the emission is nearly non-existent, while it becomes stronger at maximum (day 0) and post-maximum (day +1). The diffuse enhanced spectrum is marked with arrows.*

It might have challenged fate too much to expect a coincidence between a fourth nova and the present writer's next stay at La Silla. Thus he has recently shifted his interests to a more stable phase in the lives of novae. He now awaits allocation of observing time for the study of their nebular remnants.

Radio Observations of Comet Bradfield (1978 c)

D. Despois, E. Gerard, J. Crovisier and I. Kazès

The following story shows the importance of international collaboration in astronomy. The authors, Drs. Despois, Gerard, Crovisier und Kazès of the Département de Radioastronomie de l'Observatoire de Meudon in France, had problems in observing bright Comet Bradfield with their radio telescope, because the comet's position was not known with sufficient accuracy. Fortunately, an optical position could be secured at ESO/La Silla, although under very difficult circumstances, and an improved ephemeris was computed by Dr. B. Marsden in the USA and transmitted to France. The faint radio signal from the comet was detected, just in time to see the change-over from OH emission to absorption.

One of the objectives of cometary research is to measure the gas production of a comet versus heliocentric distance (notwithstanding possible outbursts and changes before and after perihelion) as well as the gas production from comet to comet, referring to a standard heliocentric distance of one astronomical unit. The production rate of the OH molecule is smaller than that of the H atom by only a factor of 2 or 3 and thus the monitoring of the hydroxyl radio line intensities at 1667 and 1665 MHz (the strongest of the 4 hyperfine components of the $^2\Pi_{3/2}$ ground state lambda doublet) is a good indicator of the *total* gas production.

OH in Comets

The advantage of long wavelength radio observations (~18 cm) is that the quality of the spectra is affected neither by atmospheric conditions nor by the proximity of the Sun or the Moon. We had so far studied OH in 4 comets, i.e. Kohoutek (1973 XII), Kobayashi-Berger-Milon

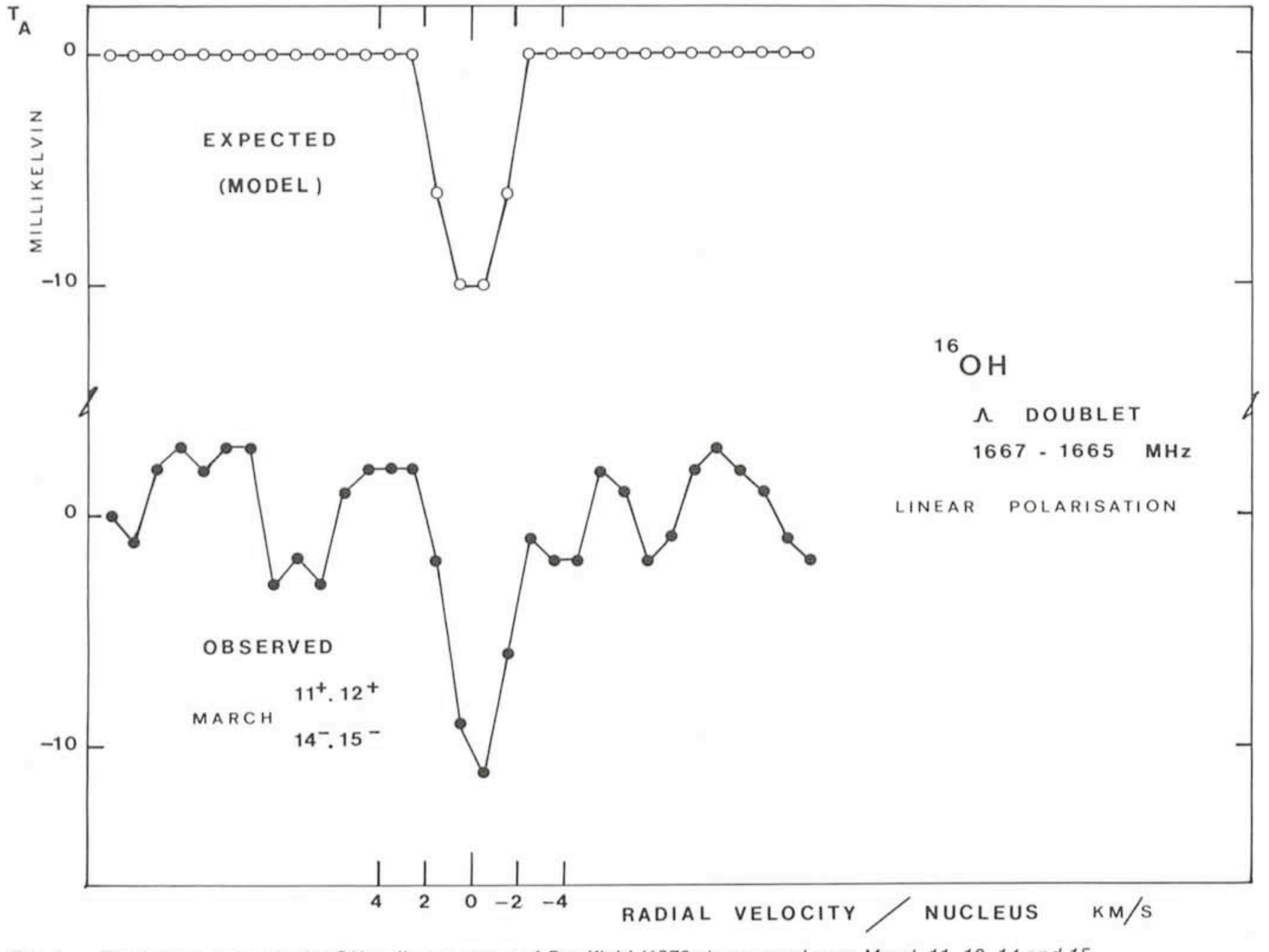
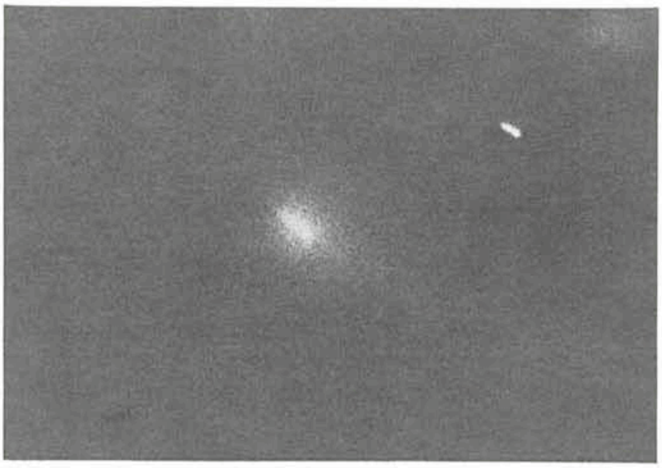


Fig. 1. — *The bottom curve is the OH radio spectrum of Bradfield (1978 c) averaged over March 11, 12, 14 and 15.*
The top curve is the OH line profile expected from a model of the OH coma with a gas production rate about one eight that of Kohoutek (1973 XII).



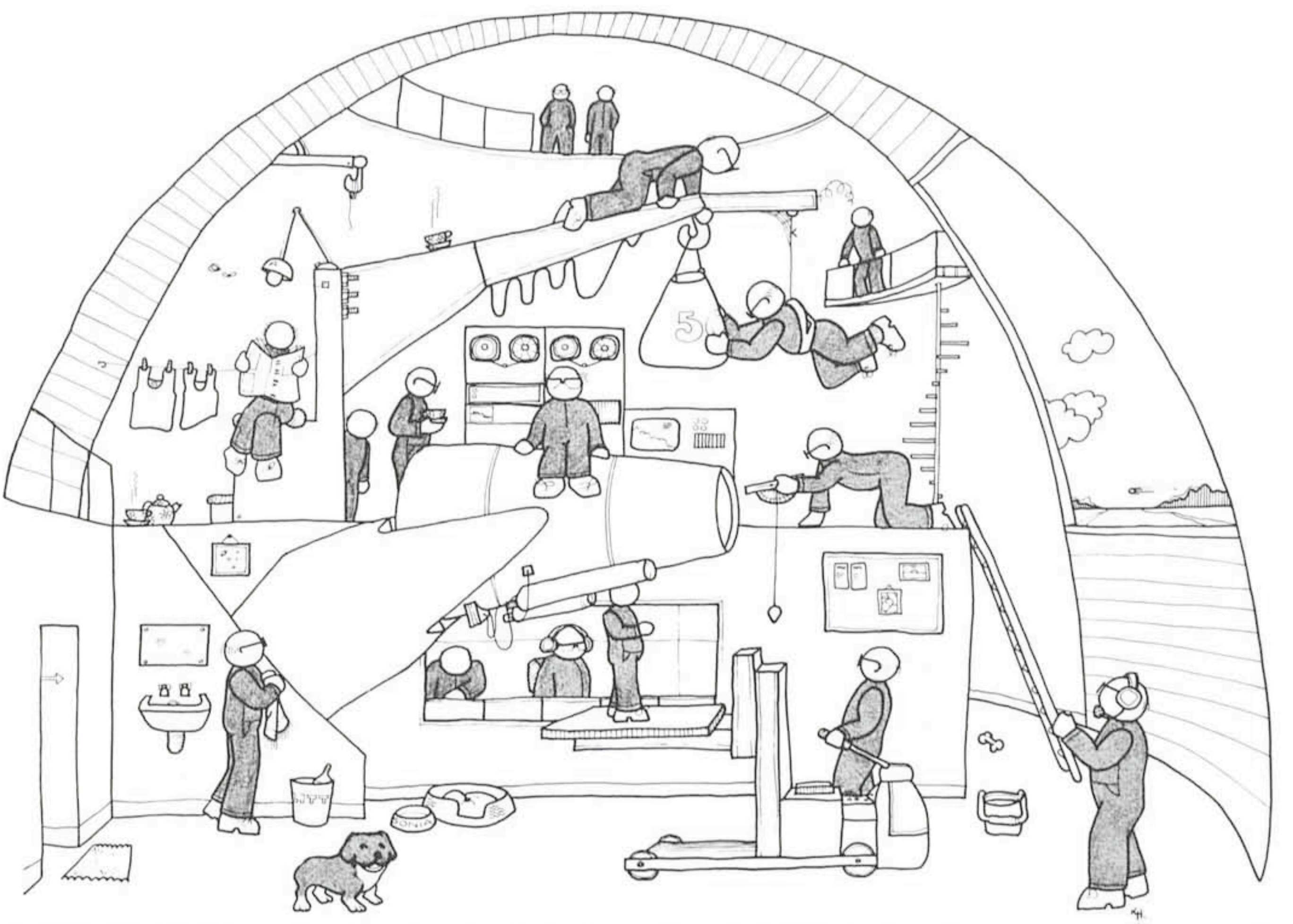
This photo of Comet Bradfield enabled the French radio astronomers to detect radio emission from the OH radical. The comet was observed under extremely difficult conditions with the ESO Schmidt telescope on March 8, 1978. At this date, it was only 25° from the Sun. A three-minute exposure was made, only 12° above the horizon, when the eastern sky was already very bright. The image is severely trailed due to differential refraction. IIa-O + GG 385.

(1975 IX), West (1976 VI) and Kohler (1977 m) with the French Nançay radio telescope, when we learned that a new bright comet, Bradfield (1978 c), was heading North and promised to reach 4th magnitude in March 1978. The major drawback of radio observations of comets is the weakness of the signal, requiring lengthy integration times to obtain a decent signal-to-noise ratio, even for a large radio telescope equipped with a cooled radiometer as we have at Nançay. Furthermore, the beam size is only 3.5 x 19 arcmin., and it is vital to know the apparent coordinates of the comet to better than 1 arcmin.

An Improved Ephemeris

We felt that the best available ephemeris (on IAU Circular No. 3177, by M. P. Candy, based on only eight observations between February 6–13) was not accurate enough when extrapolated to March 4, and preferred to divide the integration in three parts; tracking the nucleus position, 3.5′ East and 3.5′ West (the uncertainty in declination is generally small compared to the 19′ half-power beamwidth). Our upper limit to the antenna temperature on March 4 is 35 millikelvin indicating that Bradfield (1978 c) was intrinsically fainter than Kohoutek (1973 XII), at least by a factor of 3 (~ 1.2 magnitude). For lack of recent, accurate optical positions the observations had to be discontinued.

However, at our request, H.-E. Schuster succeeded in photographing the comet with the ESO Schmidt telescope and we were able to resume the radio observations with the new ephemeris (IAU Circular No. 3196). The comet was detected in emission on March 11 and 12, then in absorption



The ESO staff at La Silla went to extraordinary lengths to observe Comet Bradfield when it appeared near the eastern horizon on March 8, 1978. The above drawing, by Karen Humby (Mrs. Saxby since May 13, 1978), is based on reports of reliable eyewitnesses, but does not necessarily express the official opinion of the Organization.

on March 14 and 15. The signal changed sign on March 13 as expected from our model of the UV-pumping of the OH radical by the Sun (Biraud *et al.*, 1974, *A&A*, **34**, 163): it is a direct consequence of the Swings effect, whereby the population of the ground state lambda doublet critically depends upon the heliocentric radial velocity (Doppler shifted Fraunhofer solar spectrum).

OH Detected

The final spectrum totalizing 5 hours of integration ON source is shown on Fig. 1: it was obtained by inverting the March 11 and 12 spectra and integrating them with the March 14 and 15 spectra. The profile is well centered at the radial velocity of the nucleus and its width is ~3 km/s as expected; the amplitude, however, is only 10 millikelvin. From model calculations the OH production rate is 7 times smaller than what we anticipated from the total visual brightness announced in early February 1978 but is in satisfactory agreement with the visual magnitude observed between March 9 and 17 ($m_0 = 8.6 \pm 0.3$ instead of 6.5). In all likelihood Bradfield (1978 c) was a faint comet from the outset and the predictions were perhaps somewhat optimistic. In fact it is the faintest parabolic comet that we have measured so far at 18 cm wavelength, about 10 times weaker than Kohoutek (1973 XII) in December 1973, and 20 times weaker than West (1976 VI) in March 1976.

Accurate positions and visual magnitudes are of great interest to us. Firstly, the 18 cm OH maser gain is higher for negative heliocentric radial velocities, i.e. *before* perihelion. If we shall be able to measure new comets beyond 2 A.U., it is vital to get an accurate ephemeris *as early as possible*. On March 4, when we first observed Bradfield (1978 c), the right ascension was wrong by 1ʹ.5, and the signal halved on the Centre and West exposures; the detection would have been impossible without the accurate optical position of March 8 made at La Silla. Secondly, the visual magnitude is a good indicator of the outgassing of the nucleus, which helps us to select appropriate candidates for the study of OH gas production all along the cometary orbit.

Catching all the Photons: the CCD

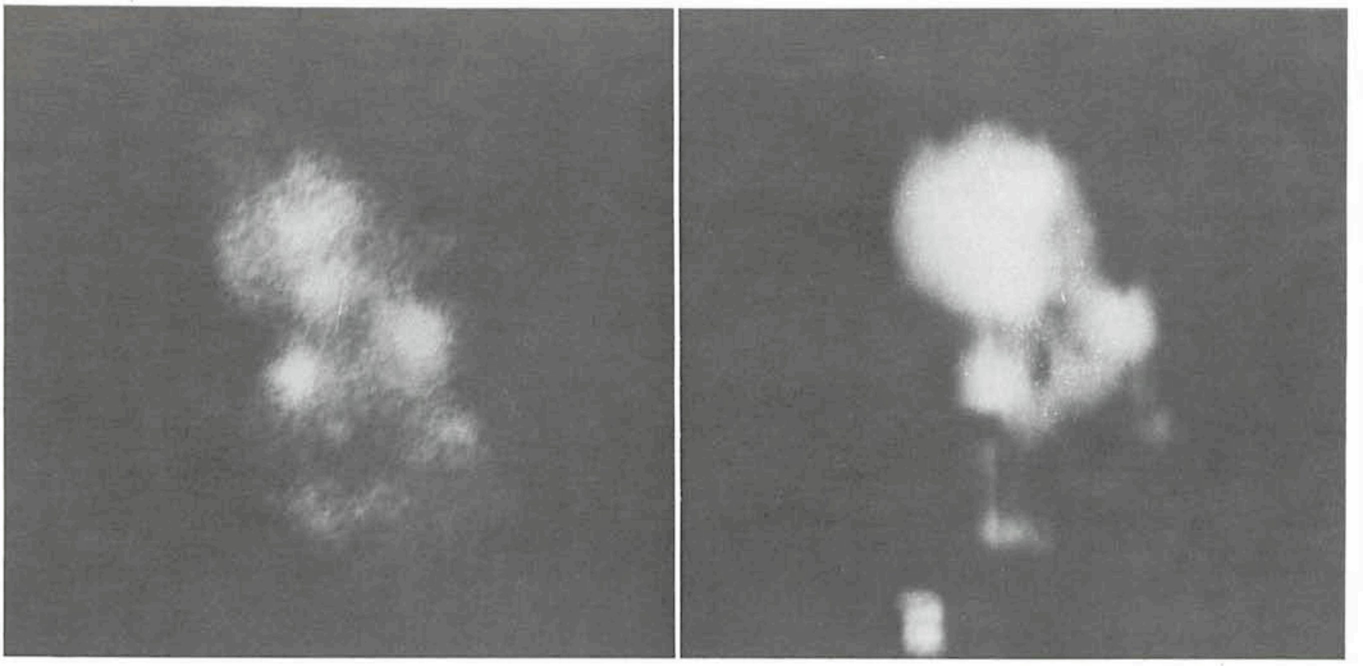
W. Wamsteker

Before you read the figure text on page 11, try to guess which of the photos was made with the ESO 1 m telescope and which with the 3.6 m telescope. The exposure times were 15 and 30 minutes, respectively. If you cannot tell the difference, then you will have been convinced of the efficiency of the new super-detector, the Charge-Coupled Device. ESO astronomer Dr. Willem Wamsteker was privileged to use a CCD on La Silla and tells us about his exciting experience.

In March of this year, ESO was given the opportunity to use at the La Silla Observatory one of the few working CCD (Charge-Coupled Device) detectors for astronomical use. This was made possible through the graciousness of our collegues at the Cerro Tololo Observatory, the generous permission of Jet Propulsion Laboratory (where the detector was developed) and the National Science Foundation which made the funds available for the operation of the detector at various observatories. The director of AURA-CTIO offered to make the JPL-CCD available to ESO for a few nights when no telescopes were available for use at their Observatory. Although the ESO telescopes are always similarly tightly scheduled, three nights could be made free at the 1 m telescope in March. Staff astronomers Drs. Wamsteker, Danks and Bouchet used these nights, assisted by Mr. Cozza (JPL) to evaluate the detector in direct imaging. The reductions were done at the CTIO computing centre in La Serena, using the basic image-processing facilities developed for AURA, in part by Dr. Albrecht (Vienna).

In the future we hope to come back in more detail on these detectors and their usefulness for astronomical observations. However, to illustrate the type of results obtained during the nights in March we show the two photos on page 11. Both pictures show the nuclear region of the nearby peculiar galaxy NGC 5253. The left-hand photograph is a direct plate taken by Dr. Wamsteker in the prime focus of the ESO 3.6 m telescope last year. The right-hand photo is a photographic reproduction (scan-converter) of a CCD frame of the same region. The text below the photographs gives the relevant details of each exposure. To compare the two photographs, it should be pointed out that the light-gathering power of the 3.6 m is about 12 times that of the 1 m, for point-like light sources; also the 3.6 m has a focal ratio about three times faster than the 1 m. Even so the exposure time on the 1 m was only half that of the 3.6 m plate. The actual resolution on both plates is about the same—limited by the mediocre seeing ~ 3 arcsec in both cases. The wavelength region chosen for the CCD exposure is essentially unaccessible to photographic emulsions.

Some of the intensity resolution in the right-hand (CCD) picture is lost in the scan conversion, which has only 16 grey levels. Even then, there exists a striking difference in the brightness distribution between the two prints. The region which dominates the right-hand picture is by far not as dominating in the left-hand photograph. Since the left-hand picture shows essentially the distribution of stellar radiation, the northern condensation is clearly associated with non-stellar radiation. This galaxy contains a strong, unresolved IR source, which is then likely to be associated with the brightest region in the right-hand photograph. The physical conditions in this must be determined on the basis of further study.



The central part of the southern galaxy NGC 5253, as seen on a conventional photographical plate at the 3.6 m telescope prime focus (left) and by a CCD at the Cassegrain focus of the ESO 1 m photometric telescope (right). Each picture measures about 33 x 33 arcseconds. Data: left photo: IV-N (H_2O sensitized) + RG 715, effective wavelength 8000 Å, exposure 30 min, 26 March 1977; right photo: JPL-CCD + RG 1000, effective wavelength 10000 Å, exposure 15 min, 19 March 1978. The orientation is the same on both photos: north is up and east to the left.

Since the wavelength region defined by the plate-filter combination of the left-hand photograph is relatively free of emission lines, it gives a good impression of the distribution of the stellar radiation in the nucleus of this galaxy. Note that the northern spot is much fainter than in the adjacent picture and has a brightness comparable to that of the other bright spots.

The right-hand picture is a scan converter photograph of the original, digital image. In the scan conversion, the digital quality of the image is nearly completely smoothed out; also a large amount of intensity information is lost in this reproduction, due to the 16 grey levels available in the scan converter. The pixel size is 23 microns.

Comparing the two photographs, one sees a considerable difference in the brightness distribution. Since the photographs were taken with broad-band filters, it is not possible to say if the great brightness of the northern dominant spot at λ = 10000 Å is due to non-thermal radiation or e.g. very strong emission in the Paschen γ and δ lines of hydrogen. The latter possibility is the more likely since this region coincides spatially with a point-like source of $H\alpha$ emission. The fainter spots are apparently rather dense stellar condensations in the centre of this galaxy. Reproductions: R. Donarski (ESO–La Silla).

Whatever Happened to NGC 5291?

H. Pedersen, P. Gammelgård, S. Laustsen

The striking, new photographs of NGC 5291 that were recently obtained with the ESO 3.6 m telescope show large amounts of material in the intergalactic space around that galaxy. How did it get there? No definitive answer can be given yet, say the authors, Drs. Holger Pedersen, Peter Gammelgård and Svend Laustsen from the Aarhus Observatory, Denmark, and ESO.

In December last year the Institute of Astronomy in Aarhus received the first batch of IIIa–J exposures taken in Australia as part of the joint ESO/SRC Sky Survey. One of the first plates we inspected was No. 445 which contains a beautiful cluster of galaxies, the IC 4329 group. Near the western edge of the cluster we recognized a pair of interacting galaxies of which NGC 5291 is the one. Such phenomena are quite common; whole catalogues devoted only to these objects have been compiled. In many cases the interacting galaxies are connected by diffuse, low luminosity bridges or they display long tails, as if tidal forces had torn the galaxies apart.

Something like that seems also to be the case with the present pair, but the appearance and large extension of the extragalactic material is quite unusual. Most of the light seems to come from small, but non-stellar knots. This is characteristic of H II regions, which are interstellar hydrogen clouds emitting light due to the illumination by hot,

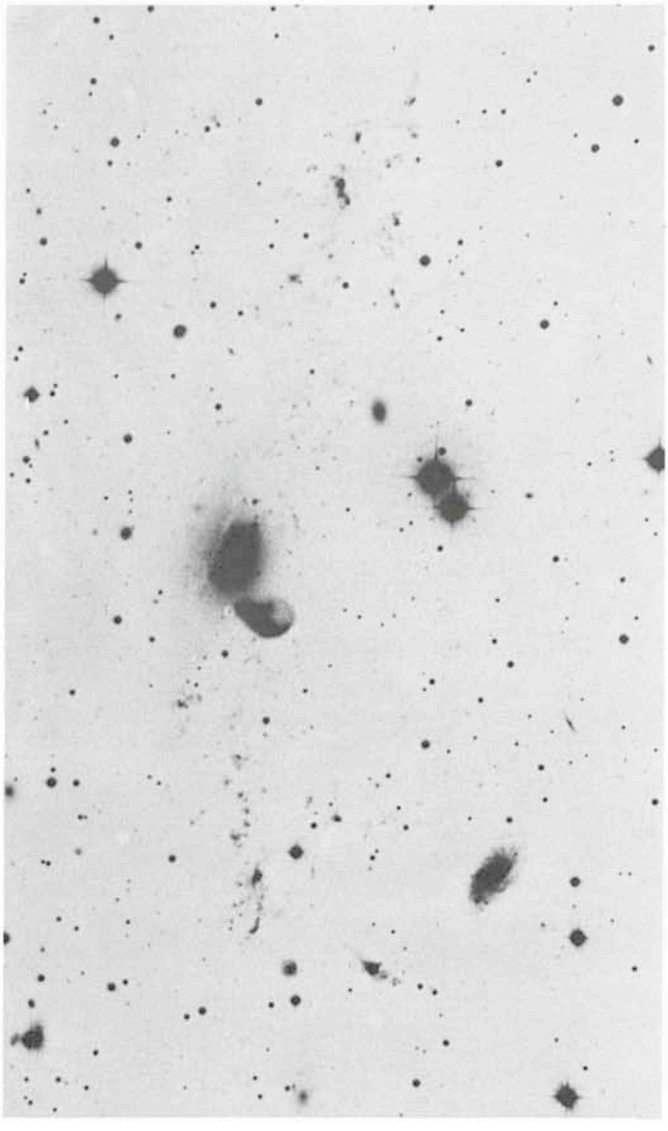


Fig. 1. — *The irregular tails around NGC 5291 and its companion galaxy. The material can be traced over 9 arc min which corresponds to 200 kpc at the distance of NGC 5291. Remark also the absorption lane crossing the eastern part of NGC 5291. The plate is an unfiltered 60-min exposure on IIIa–J. North is up and east to the left.*

luminous stars imbedded in the gas. But since the outermost knots are separated by as much as 100 kpc from NGC 5291, the transfer time of material drawn out would exceed by orders of magnitude the short life-time of the exciting stars.

The nature of the extragalactic material was therefore an open question, and since one of us had observing time on the 3.6 m telescope at La Silla, we decided to pursue the matter by some further observations. Plates were taken in the prime focus on two nights in March 1978. One of the plates (Fig. 1) is an unfiltered 60-minute exposure which was taken during the night March 9–10 when the seeing was good, about 1″. Another plate, a 60-minute red exposure, was taken two nights later when the seeing was inferior, about 3″. The first of these plates confirmed the knotted structure of the extragalactic material and a comparison of the two plates shows that it is clearly bluer than the galaxies in the field. These facts have led to an interpretation in terms of "extragalactic H II regions".

Such an interpretation does, however, call for further confirmation and we hope to be able to continue our studies, in particular by obtaining spectra of some of the brightest knots. But the knots are faint and the task will consume considerable time, even at a large telescope.

PERSONNEL MOVEMENTS

(A) Staff

ARRIVALS

Garching

Gisela VOSSEN (German), secretary, 1.6.1978

Geneva

Alain PERRIGOUARD (French), systems programmer, 1.4.1978

Roy SAXBY (British), photographer, 1.5.1978

DEPARTURES

Garching

Imke HEIDTMANN (Swedish), secretary, 31.5.1978

Geneva

Sten MILNER (Danish), mechanical engineer, 31.3.1978

Rudolf ZURBUCHEN (Swiss), electronics engineer, 30.4.1978

(B) Paid Associates – Fellows – Coopérants

ARRIVALS

Geneva

Scientific Group: Jean SURDEJ (French), Fellow, 27.5.1978

La Silla

Patrice BOUCHET (French), Fellow, 1.6.1978

With great grief we have learned that

Svend Bohn Lorensen

1942–1978

died suddenly in Copenhagen on March 1st, as a result of a serious illness. He leaves three children.

Svend, who joined ESO in 1971, had an early interest in astronomy (his father is also an astronomer although he later became a teacher) and concluded his studies at the Copenhagen University Observatory in 1969 with a brillant Ph.D. Svend could have made important contributions in any astronomical field of his choice, and he soon developed a special interest in the application of highly sophisticated computer techniques in astronomy, a field in which he became a leading figure. He was the author of the control software for many of the ESO telescopes, in particular the 3.6 metre, in high esteem by visiting astronomers. Much of the present and future ESO software is due to his foresighted ideas. A sudden deterioration of his health forced him to return to Copenhagen by the end of 1977 to undergo continuous medical treatment.

Svend was a true friend to his friends, and all of us who knew him—at ESO and elsewhere—can testify to his eagerness to help whenever and wherever needed. His modesty about his important accomplishments was legendary. He was always optimistic and continued to teach student classes until the day before his death. He had an inquisitive scientific mind with a great interest in artistic fields, he was a great music lover and a very good piano and organ player.

We all miss him very much. Richard M. West

ESO Workshop on Modern Techniques in Astronomical Photography

A workshop on the above subject took place in Geneva, Switzerland, on May 16–18, 1978. It was organized by the European Southern Observatory, in collaboration with the Working Group on Photographic Problems of the International Astronomical Union.

During three days, about 65 participants from 19 countries discussed the latest news in the field of astronomical photography. Review papers were presented about the dramatic history of photography of the skies (Wm. C. Miller, Hale Observatories, Pasadena), the newest hypersensitizing techniques (M. E. Sim, Royal Observatory, Edinburgh), the all-important photometric calibration of the plates (A. A. Hoag, Lowell Observatory, Flagstaff) and other subjects. These included colour photography (beauty versus scientific value!), copying of plates and special photographic techniques (or rather magics) to bring out what you do not see in the photos, but what is really there (very faint details or overexposed). The current photographic work at some of the world's leading telescopes was also described, well illustrated by photos—also from the soviet 6 metre telescope.

The workshop clearly demonstrated the enormous potential of photography in astronomy. Although some applications are now being taken over by other, mainly electronic detectors of higher quantum efficiency, the photographic plate is still the only detector available for large-scale information storage (10^{10} bits on a single 14 x 14 inch plate!) and, for many other purposes, by far the cheapest and easiest to use.

The main conclusions of the workshop were brilliantly summarized by Dr. Al Millikan (Kodak, Rochester) who is also the chairman of the Working Group on Photographic Materials of the American Astronomical Society. Specific recommendations for optimum use (including hypersensitization and calibration) of the various types of emulsions were given. This information will be of great value for photographic work at the observatories—and not the least for interested amateur astronomers.

The Proceedings have been edited by R. M. West (ESO) and J.-L. Heudier (Nice Observatory) and will be available by the end of June 1978.

Proceedings of the ESO Workshop on Modern Techniques in Astronomical Photography

The Proceedings of this workshop have now been edited and will be available in print by the end of June 1978.

The price for the 300-page volume is Sw. Fr. 16.– (in Europe) and US $ 10.– (elsewhere), including postage. Please send your order to:

European Southern Observatory
c/o CERN
Attn. Miss M. Carvalho
CH–1211 Geneva 23

Sign-posts of Star Formation in Interstellar Clouds South of Declination –30 Degrees

G. F. Gahm

A major investigation of star formation in the southern hemisphere was recently undertaken by Dr. Gösta F. Gahm from the Stockholm Observatory at Saltsjöbaden, Sweden. He obtained direct plates and spectra with the 3.6 m telescope and here reports some very interesting preliminary results. Working with a newly-commissioned telescope may also create some exciting moments . . .

The galactic dark cloud complexes south of declination -30° have not been studied in as much detail as the corresponding complexes north of this limit. This circumstance is of course a result of the previous paucity of large optical, infrared and mm-telescopes in the southern hemisphere.

However, there is a number of interesting regions south of -30°. For instance, there are two clouds in the Chamaeleon constellation, close to the southern celestial pole, at $\delta = -77^\circ$. These clouds contain a number of recognized pre-main-sequence objects, like T. Tauri stars and the so-called Herbig type Ae- and Be-stars. Also, there are Herbig-Haro objects which are often found in regions of star formation. The Chamaeleon associations are the nearest regions of star formation that we know of, and we may therefore observe intrinsically fainter stars in pre-main-sequence phases of evolution in these clouds than in others. The most extensively studied region in the southern sky is the η Carinae nebula, which is a relatively distant giant H II region, very complex and with a number of interesting features as observed at optical, infrared and radio frequencies.

The Coalsack

The well-known Southern Coalsack is another region which has been subject to several studies. This dark cloud is remarkable in the sense that there are no sign-posts of star formation known so far. The fact that the region contains a number of Barnard-Bok globules may or may not be taken as an indication that star-formation processes have started. We do not know, however, whether the Southern Coalsack is a virgin interstellar cloud in a very early stage

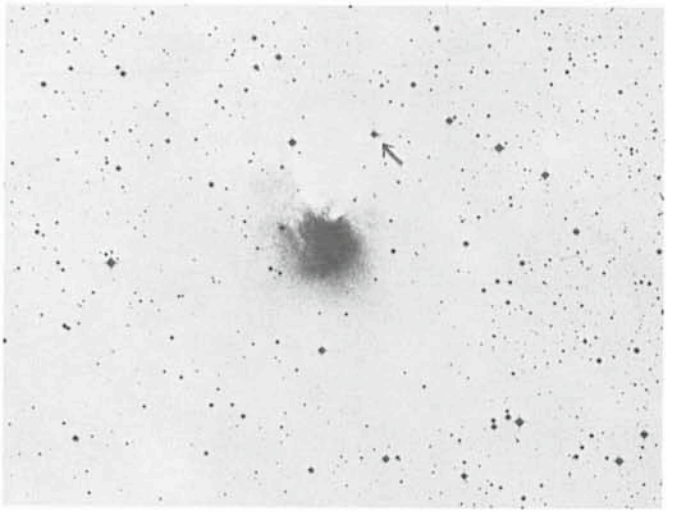


Fig. 1. — *NGC 2264 is connected to a relatively nearby, compact cloud where a bright (dark in this negative print) reflection and emission nebula is generated by a B1 V star in the cloud. The star at the arrow turns out to be a B9 V star with emission structures at the Hβ line. This star is the centre of a small reflection nebula. A few additional stars in this region were observed but were found to be foreground stars.*

preceding that of widespread star formation, or if the physical properties in the cloud are such as to prevent stars from forming. Future observations over the infrared and mm wavelengths will be most helpful in claryfying the nature of this cloud complex. It is understandable that astronomers hesitate to start long-wave mapping of such an extensive region in the sky, since the outcome of the programme may very well lead to publications entitled "A negative search for . . .". However, even if such mappings will only lead to few discoveries, they may still tell us important things about the processes that do occur or do not occur in dark interstellar clouds.

With the ESO 3.6 m telescope in operation one can start to think of a number of useful programmes directed towards a deeper understanding of star formation and early stellar evolution. The "great leaps" forward in describing the physical conditions of young stars will undoubtedly come from higher spectral and/or spatial resolution. There also appears to be much information to gain from repeated high-speed photometric and spectroscopic observations. It is my hope that the 3.6 m will soon provide facilities for such observations.

3.6 m Observations

At the moment, the 3.6 m can be used with the Boller and Chivens spectrograph plus the Carnegie image tube to obtain slit spectrograms at dispersions of 60 Å/mm and lower. It is of course tempting to start spectral investigations of the intrinsically faint members of the nearest young stellar associations. We thought, however, that as a first step it would be of value to make an inventory of southern dark cloud regions with sign-posts of star formation. As sign-posts of star formation we consider stellar groups seen in dark nebulae where at least one star is surrounded by an emission and/or reflection nebula. Such regions can often be grouped in what is generally referred to as R-associations.

We therefore searched the ESO "Quick Blue" Sky Atlas for such regions, giving emphasis to regions located in the general area of the Southern Coalsack. Telescope time for spectroscopic observations of the stars in such bright nebulosities was allotted in March 1978, and when additional time was offered due to programme changes on La Silla, it was possible to extend the programme to include a total of 25 regions south of declination −30°.

Many of these stellar groups with associated bright nebulosities have been observed previously by S. van den Bergh and W. Herbst. Their survey gives important information on the U, B and V magnitudes for a number of stars and in some cases also the spectral type for the brightest member or members in the group. With the 3.6 m it was possible to extend the spectral survey to include stars from 12th to 17th magnitude. All spectrograms were taken at a dispersion of 60 Å/mm and are in general widened to 0.4 mm.

The observational material is now under reduction and I do the work in collaboration with Miss Margareta Malmort. Most of the stars turn out to be normal O and B stars on the main sequence. Some stars are situated in bright H II regions, some are not. We derive the distance to each region which makes it possible to check whether a given region belongs to an established R-association or not. These associations are then used to map the corresponding galactic structure. The spectral survey immediately tells us which stars are members and which are not members of the stellar groups. It is our hope that the survey will prove to be useful as a background for future studies of southern regions of star formation.

Emission-line Stars

Several stars of spectral types B or A show strong and broad Balmer line emission. These stars are likely to be pre-main-sequence stars of the Herbig Ae- or Be-type. There are also examples of stars with metal-line emission. The most conspicuous example is the star listed as No. 65 b by van den Bergh and Herbst (vdBH 65b). This star, situated in a cometary nebula, shows a very interesting spectrum with strong P Cygni-type profiles in several lines. The star was listed by Sanduleak and Stephenson as a suspected

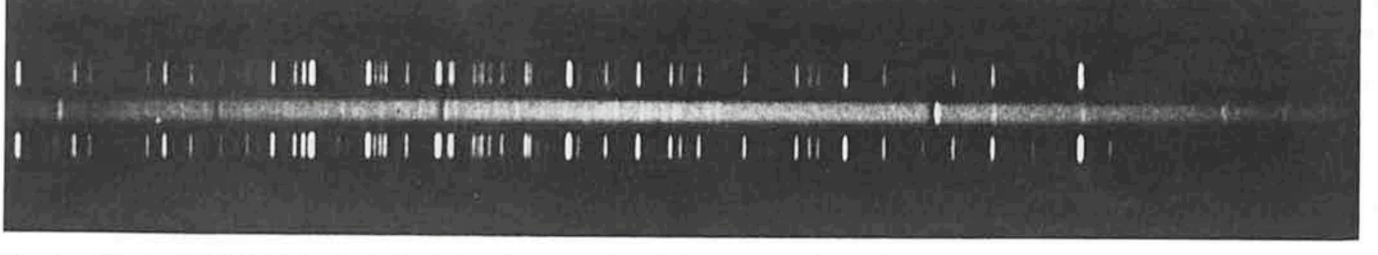


Fig. 2. — *The star vdBH 65 b is situated in a cometary nebula and shows a very interesting spectrum, rich in emission lines and with P Cygni structures in several lines.*

symbiotic star. The present investigation suggests that this object is a pre-main-sequence star with a remarkable spectrum.

Special attention is given to the regions in the general area of the Southern Coalsack. If any of these bright nebulosities are associated with the Coalsack, they could guide us into local regions of star formation in the large dark cloud complex. They would be important starting points for infrared and radio studies. The spectroscopic material has not revealed any associated regions, however. In fact, certain regions that are seen in the middle of the Coalsack turn out to be very distant background objects. One small bright nebula at $\alpha = 12^h45^m33^s$, $\delta = -63^\circ33'38''$ (Object No. 1) seems to be associated to the Coalsack, however. In this nebula there is no star. I took a series of direct plates in the prime focus of the 3.6 m of this nebula as well as of a few others. A comparison between V (visual) and I (infrared) plates reveals no extremely red objects in the area around Object No. 1. We are uncertain to the nature of this object. In other regions we have discovered some extremely red objects from the prime focus plates.

Horror in the Dark

The prime focus nights were quite exciting and once the instrument somehow got disconnected and started to move towards the horizon. I could see my whole life passing by when sitting in the cage and searching for the emergency switch. Also the nights at the Cassegrain focus were not entirely without instrumental problems. The present system with several visiting astronomers staying over a 17-night period is, I believe, to prefer at the moment. In this way there is a fair chance that you will have your observational material complete at the end of the run. Looking upon it in this way I am quite satisfied with my first run at the 3.6 m on La Silla.

RR Lyrae Stars

J. Lub

The variable RR Lyrae stars are among the most important distance indicators in the Galaxy and its nearest neighbours. To obtain the highest precision, it is, however, necessary to know the physical characteristics of the individual RR Lyrae stars. This knowledge in turn is very valuable for studies of the stellar system (galaxy or cluster) in which the RR Lyrae star is a member. Dr. Jan Lub from the ESO Scientific Group in Geneva has recently terminated a first phase of a large investigation of RR Lyrae stars. He summarizes what can be learned from the study of RR Lyrae stars by means of accurate photometry, sometimes supported by spectroscopy.

A quick look in Kukarkin's 1969 edition of the General Catalogue of Variable Stars shows a striking number classified as RR Lyrae variables. In fact about two-thirds of all the stars listed (more than 20,000) belong to the class of pulsating variable stars, the most common of which are the RR Lyrae with 4,433 entries. Apart from that, over one thousand have been found in the globular clusters belonging to our galaxy and more than a hundred have already been identified in the Magellanic Clouds.

Two types can be discerned among the RR Lyrae stars: either the *ab-type* with asymmetric ("saw tooth") light curves, visual amplitudes ranging from $1^m.3$ to $0^m.4$ and periods in the range $0^d.8$ to $0^d.3$ or the *c-type* with symmetric (sinusoidal) light curves, having amplitudes of $0''.5$ and lower, and periods ranging from $0^d.45$ to $0^d.25$. There is no physical difference between these two classes; the c-type RR Lyrae being first overtone pulsations, whereas the ab's pulsate in the fundamental mode. It goes without saying that the large amplitude of the light variation and the rather short period make the detection of these variables rather easy; a fact which largely explains the large number which have been found in the various surveys.

The Importance of Studying RR Lyrae Variables

The importance of the study of RR Lyrae stars is at least threefold: first they can be used as "standard candles" in distance determinations, and secondly they provide us with information on the chemical composition (helium and heavy element abundance) in the halo and old disk population of our galaxy. Finally, they are important test objects for a large amount of theoretical work in stellar structure and evolution and hydrodynamics. Accurate photometric data are a first prerequisite for such studies, because we need such quantities as mean light intensity, interstellar reddening, blanketing and especially in connection with the last and first points, temperature, surface gravity and radius variation.

As to the first point: on quite general grounds one expects the existence of a Period-Luminosity-Colour (Temperature) relation for any class of pulsating variable stars. For example, for the *Cepheids* with their wide range in age (and thus mass), this becomes the well-known *Period-Luminosity* relation: the colour (i. e. the width of the instability strip) being of secondary importance. This is in strong contrast to the case of the *RR Lyrae* stars where there exists a *Period-Colour* relation, the luminosities being rather similar, due to their approximately equal age (and thus mass). This luminosity has been derived by the method of statistical parallaxes or from main-sequence filling of globular clusters and an absolute visual magnitude of about $0^m.7$–$0^m.5$ is found in such a way.

A study of the strength of the Ca II K line in the spectra of RR Lyrae stars at minimum light by Preston revealed a large range in metal abundance. Moreover, he found a strong correlation between the kinematical properties of a group of field variables and their heavy element abundances in the sense that a larger solar motion and residual velocity dispersion is found for low metal-line strength. It is obviously of importance to study the dependence of other observable properties of RR Lyrae stars, such as the luminosity, the periods, the intrinsic colours upon metal abundance.

Such improved knowledge will make it possible to improve the determination of the distance to the Galactic centre, or even the Magellanic Clouds. Also RR Lyrae stars are suitable as a probe of the halo component of our galaxy, and could give important information on the densities and heavy element abundances at large distances to the galactic plane.

Photometric Observations

At Leiden Observatory, Dr. G. van Herk initiated a large survey of southern RR Lyrae stars as a follow-up to his detailed study of the kinematics and the statistical parallaxes of the field RR Lyrae stars. Starting from the late sixties, about 100 completely covered photoelectric light curves were obtained mainly by Dr. A.M. van Genderen using the Walraven five-channel simultaneous photometer attached to the 92 cm photometric telescope—"the light collector"—at the Leiden Southern Station near Hartebeespoortdam, South Africa. Some observations were also made by Drs. W. Wamsteker and J.W. Pel; the reduction and discussion of the material—the equivalent of over 200 complete observing nights—was done by myself. (An atlas of light and colour curves has been published in *Astron. Astrophys. Suppl.* **29**, 345, 1977.) As an example, we show in Fig. 1 the blue (B, λ = 4325) light curve of the extremely metal-poor variable V 675 Sgr. Note that these light curves are not featureless: in this case there is a strong hump at minimum light and a change in slope at mid-rising light. A quick glance through the above-mentioned atlas shows many more interesting features on the various light curves.

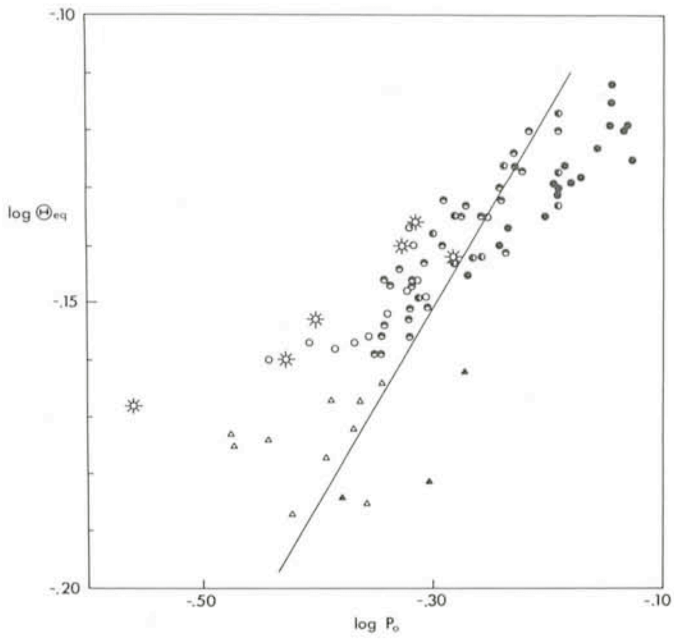


Fig. 2. — *The period-temperature plane for RR Lyrae stars. Along the vertical axis is plotted log Θ_{eq} where Θ_{eq} = 5040/T_{eff}, and along the horizontal axis log P_0 where P_0 is the period in days. c-type variables have been plotted at the position of their fundamentalized period (= log P + 0.128) and are indicated by triangles. The metal abundance of the RR ab star is indicated by various shadings: ● $Z<3 \times 10^{-4}$; ◐ $Z\sim5 \times 10^{-4}$; ◓ $Z\sim 10^{-3}$; ○ $Z\sim4 \times 10^{-3}$; ☼: "solar abundance". The drawn line is the relation predicted from pulsation theory at a constant mass-luminosity ratio.*

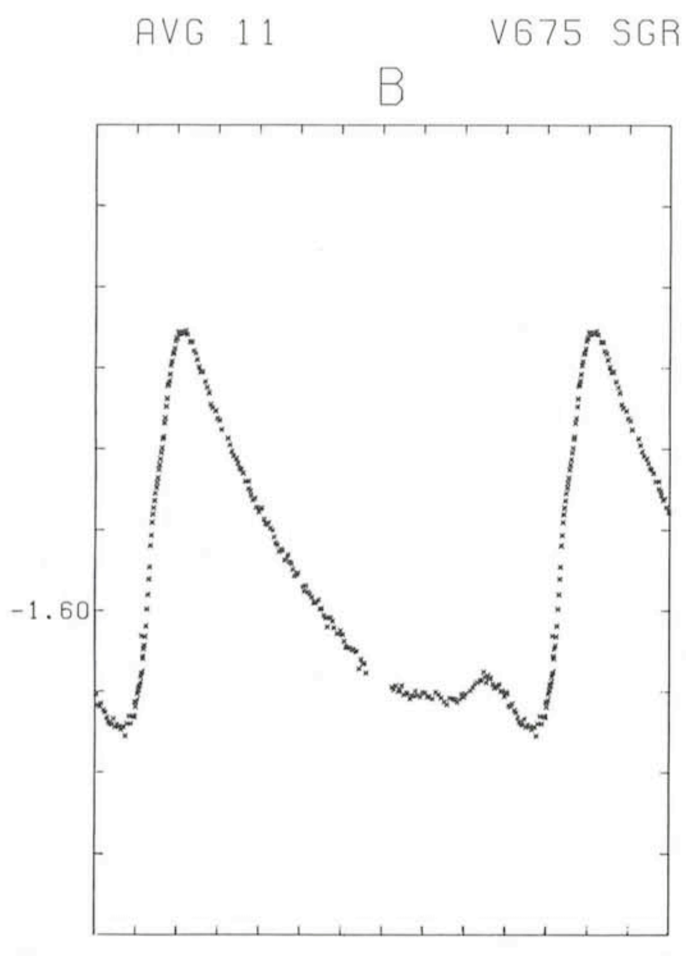


Fig. 1. — *B light curve (Walraven system) of the extremely metal-poor ab RR Lyrae variable V 675 Sgr. Each subdivision on the vertical scale is 0.10 in units of ^{10}log (Intensity). Phase is indicated on the horizontal axis ranging from 0.8 in steps of 0.1 to 0.2, including one full period.*

The Walraven System

An up-to-date description of the properties of the Walraven VBLUW photometric system has been given by J.W. Pel and the author in a paper published in *Astron. Astrophys.* **54,** 137 (1977). The characteristics of the photometric bands are summarized in the table below:

		V	B	L	U	W
effective wavelength	λ	5470	4325	3840	3630	3260
band width	$\Delta\lambda$	720	450	225	240	140

which has been taken from that paper. From multicolour photometry one can in principle deduce the three parameters which (mainly) determine the shape of the emergent stellar spectrum: the effective temperature, surface pressure (or gravity) and the abundance of the "heavy elements".

In the case of the RR Lyrae stars one measures T_{eff} and logg using (V–B) and (L–U), both expressed in units of ^{10}log (Intensity), while the blanketing due to the iron peak elements is derived from the amount of blanketing present in the L-band measured by (B–L). Of course the first two physical parameters mentioned do vary over the pulsation cycle, and in this respect the Walraven photometer is very well adapted to the study of variable stars, because all five intensities are measured simultaneously. One important complication should be mentioned here: due to the existence of interstellar reddening one needs at least three two-colour diagrams for the determination of the physical parameters; this is apart from the important question of how to fix the zeropoint of the colour excesses.

Along these lines we have succeeded in measuring very accurately the blanketing in the ab-type RR Lyrae stars as was ascertained by comparing with, for example, Preston's Ca II K line strength parameter ΔS. Accurate metal abundances can now be attributed to over 200 stars and a study of various subgroupings in order to determine solar motion and statistical parallaxes is well under way.

Possibly even more interesting is the fact that we can derive temperature and surface gravity variations for all stars on our programme over their pulsation cycle. Several roads to study are thus opened. Combined with the light curve variation it is possible to determine the relative variation of radius for each star. Unfortunately only a few (one in our case), well-covered (and accurate!) radial velocity curves are available such that we might derive the actual radius excursion, and finally the radius and absolute luminosity—this is known as the Baade-Wesselink method. However, combining our knowledge of radius and temperature variation, it is possible to determine the temperature of the equilibrium state of a pulsating star.

Physical Properties of RR Lyrae Stars

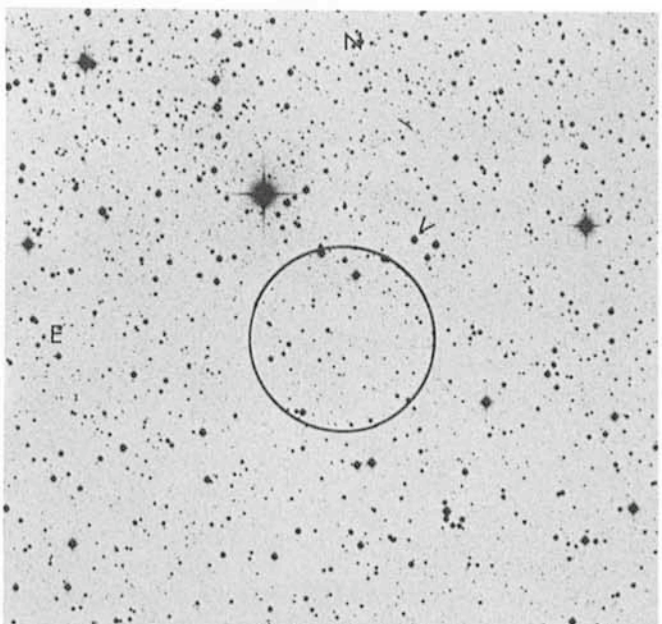
A study of the period-temperature plane reveals several important properties of the field RR Lyrae stars: as a function of metal abundance, well-defined regions are discernible in Fig. 2. At a heavy element abundance $Z = 10^{-3}$ by mass (compared with $Z \simeq 0.02$ for the Sun) we derive in this way a helium abundance by mass $Y \simeq 0.25$ and a visual absolute magnitude $M_v \sim 0.5$. The high temperature boundary of the instability region provides another estimate of the helium abundance which also comes out at about the same value $Y \simeq 0.24$. The main uncertainty in such a determination resides in the accuracy of the adopted temperature scale: errors of up to 100 K are likely and lead to a change in the estimated helium abundance by about 0.025. The possible uncertainty in the theory is very difficult to estimate, but should be kept in mind.

The existence of such a clear division among the metal-poor RR Lyrae stars is reminiscent of the two subgroups which one finds among the globular clusters containing RR Lyrae variables. It will thus be of interest to extend the present work with measurements of the variables in some of the nearby clusters, which in principle is possible with a 1 m photometric telescope; such observations were indeed already made by J. Pousen in 1962 using the present equipment.

Optical Observations of Galactic X-ray Transients

M. Pakull

Dr. Manfred Pakull, of the ESO Scientific Group in Geneva, works on the optical identification of X-ray sources. During the past years, he has performed photometric and spectroscopic observations of stars near error boxes of X-ray sources. It is very difficult to be absolutely sure of an identification until synchronous variation of the X-ray and optical intensity has been demonstrated. He reports the possible identification of the transient X-ray source MX 0656-07, with a 12^m star.



Error circle of MX 0656-07 superimposed on a print from the ESO (B) Atlas. The Be star mentioned in the text is marked by the V.

The number of known X-ray sources in the sky increases rapidly. The latest compilation of sources observed by the pioneering UHURU satellite (4U catalogue) comprises more than 300 entries. Their distribution shows a strong concentration towards the galactic centre, proving that a large fraction of the sources belong to our galaxy.

Except for the X-ray emitting supernova remnants (SNR), most of the galactic sources are strongly variable on time scales of milliseconds up to years. Some sources suddenly brighten up from invisibility to become the most luminous objects in the X-ray sky for a few days and subsequently decline below the threshold of the detectors. They are commonly referred to as X-ray Novae or Transients.

And, indeed, the X-ray novae A 0620-00, TrA X-1 and H 1705-25 have been identified with optical novae. These three sources share many characteristics, as for instance soft X-ray spectra and lack of regular X-ray pulsations. Moreover, the transient A 1744-36 might correspond to the optical nova Hen 1481. It appeared in 1951 at the position of the X-ray source. If this identification is correct A 1744-36 is a recurrent X-ray/optical nova like A 0620-00.

Another class of transients display very hard spectra and mostly regular X-ray pulsations. No corresponding optical novae have been observed at their positions. A 0535+26, 4U 0115+63 and A 1118-60, the "X-mas" source (since it flared up on Christmas 1974), belong to this group. There is now growing evidence that they might be related to Be stars, early-type main-sequence stars spinning at their break-up velocity.

Unfortunately, positions of most transients are not very accurately determined. Therefore the chance of accidental associations should be kept in mind.

Be stars are, however, also found as optical counterparts of persistent X-ray sources, notably 4U 0352+30 = X Per, MX 0053+60 = γ Cas and 4U 1145-61 = Hen 715.

Observations on La Silla

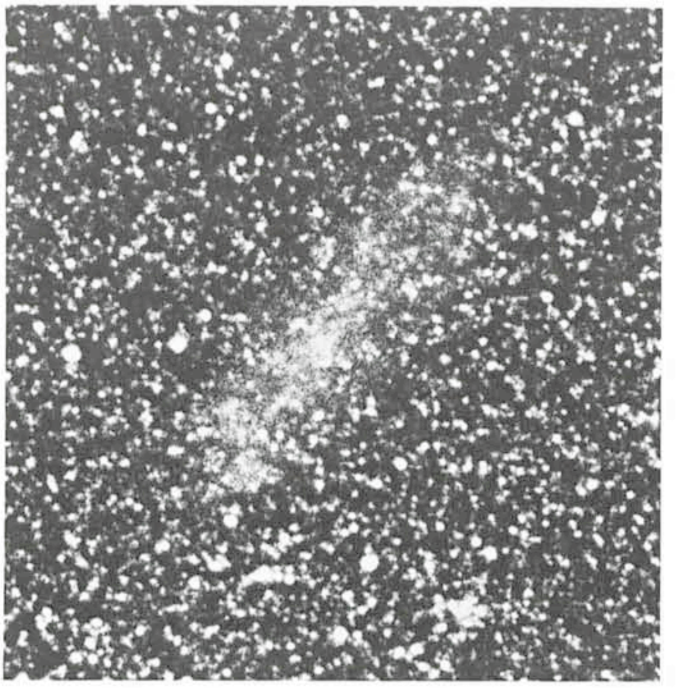
A number of X-ray error boxes have been observed during the last two years with the ESO 50 cm, 100 cm and 152 cm telescopes. An early-type star like a Be star might easily be detected by means of UBV photometry, even on nights of poor photometric quality. Subsequent observations of candidates, however, need "good" nights to detect variations, which could be less than 0.05 magnitude.

The proposed identification of the transient MX 0656-07 with a Be star may serve as an illustrative example. This source was detected by the SAS-3 satellite in September 1975. Subsequently, Schmidt and Angel searched in vain for a corresponding new star. Later the position was refined by Ariel 5 to a 90 per cent error circle of 3 arcmin radius, which made a photometric survey feasible.

UBV photometry of about 20 stars revealed a reddened early-type star of visual magnitude V = 12.35 and colours (B – V) = 0.87, (U – B) = –0.16 with possible variations of a few hundreds of a magnitude in the following nights.

In January 1978, Dr. West kindly took two short-exposure, 123 Å/mm spectra with the 3.6 m telescope confirming the early spectral type of about B2. Hα and Hβ are clearly seen in emission and the presence of many strong interstellar lines confirms the high reddening of E_{B-V} = 1.0. Spectroscopic observations with higher resolution and more photometry are planned to determine its luminosity and to reveal possible periodic light variations as seen in most X-ray binaries. As was mentioned earlier, the possibility of a chance coincidence cannot be ruled out completely, although the apparent density of Be stars in this direction of the galactic plane turns out to be quite low.

Future observations, preferably to be carried out simultaneously in the X-ray and optical band, and the possible detection of transients at a very low level with more sensitive satellites as HEAO-B will help us to understand the underlying mechanisms of X-ray outbursts in these most interesting systems.



NGC 1809: Behind the LMC

▲

The object NGC 1809 has long been known. It lies southwest of the central bar in the Large Magellanic Cloud and is apparently heavily obscured by the LMC stars. The photo is reproduced from ESO Quick Blue Survey plate No. 1133 of field 56, which was obtained in 1975 with the ESO Schmidt telescope. It shows NGC 1809 as an elliptical nebula with a central condensation.

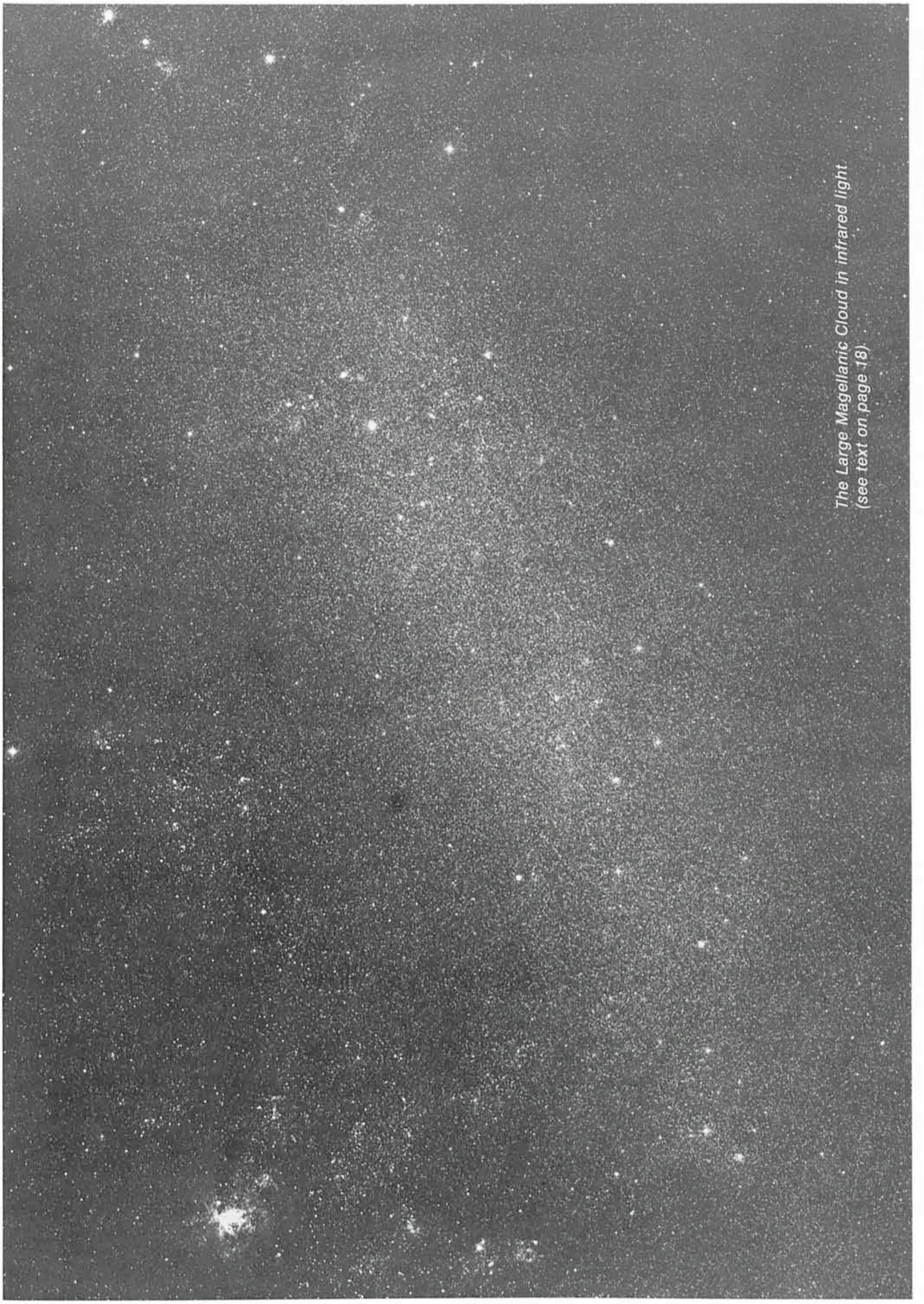
It is obviously rather difficult to obtain a spectrum of this object, due to the large number of LMC stars. Nevertheless, a 20-min 123 Å/mm spectrum with the Cassegrain spectrograph on the 3.6 m telescope just shows some weak emission lines on top of the heavy LMC stellar background. The velocity is about 1,000 km/s, much too high to make NGC 1809 a member of the LMC. It is therefore a galaxy behind the LMC, shining dimly through the absorbing layers of dust in the LMC. It is also possible that NGC 1809 is associated with a radio source in the most recent Parkes catalogue of southern radio sources.

The detailed results are being published in a note in Astronomy and Astrophysics by ESO astronomer R. M. West.

The Large Magellanic Cloud in Infrared Light!

Deep plates of the Magellanic Clouds are presently being compiled at the European Southern Observatory, by means of the 1 m Schmidt telescope. On page 19 we show the Large Cloud as it looks in infrared light (7000–9000 Å) on a unique IV-N plate, obtained on January 16, 1978, behind a RG715 filter. The exposure time was one hour. The plate was sensitized and guided by Guido Pizarro. The plate is remarkable because of its uniformity; normally it is very difficult to hypersensitize infrared plates without the risk of large non-uniformities. Water (H_2O) and ammonium (NH_3) were used for this plate.

It shows mainly the redder stars in the LMC and suppresses the gaseous nebula. The stars are resolved even in the central part of the bar. The nebula to the upper left is 30 Doradus, the brightest H II region in the LMC. ▶



The Large Magellanic Cloud in infrared light
(see text on page 18).

Supernova Remnants: What Do They Tell Us about Massive Star Evolution and the Interstellar Medium?

M. Dennefeld

Ever since that spectacular death of a heavy star in the constellation Taurus was recorded in ancient China, astronomers have wondered about what really happens when a supernova explodes. It is true that the discovery of pulsars has brought us a long step forward, but there are still many mysteries to be solved. Dr. Michel Dennefeld, of the Scientific Group in Geneva, reviews our present knowledge and shows how the study of supernova remnants may eventually lead to a better understanding, not only about a supernova itself, but also about the surrounding interstellar medium.

Like many other objects in the sky, the study of supernova remnants (hereafter called SNR's) has greatly benefitted in the last few years from the increased technical possibilities, both in sensitivity and in spectral range. Interestingly enough, the only objects which were already studied in some detail in the 1950's or earlier, namely the Crab Nebula, the Cygnus Loop and Cas A, are now known to be representative each of a different aspect of the SNR's: Cas A is a young SNR believed to have been born around 1670, the Cygnus Loop is a much older remnant (around 20,000 years old) whose aspect is due to strong interaction with the surrounding medium, and the Crab, while young, is peculiar (still the only object definitely known in its category) because the pulsar in its centre is the active source of energy for the surrounding nebula.

The Evolution of SNR's

The dynamical evolution of an individual SNR shell can be conveniently divided into four phases. In the first phase, the ejected material is expanding freely and the situation is governed by the properties of the initial explosion. But as soon as the expanding shock-front has swept up a mass of surrounding interstellar material of the same order as the ejected mass, this heated interstellar medium starts to dominate and the SNR enters phase 2, which lasts as long as the integrated losses of energy are negligible with respect to the initial energy (this phase is therefore also called the *adiabatic* phase). When this is no longer true, we are in phase 3 where radiative cooling losses are important. The matter that passes through the shock-front cools rapidly, the density becomes high and a thin shell is forming, which can be considered to move with constant linear momentum. The thermal energy in the object is now small compared to the kinetic energy (this phase is also called the *radiative* phase). In the last phase, the expansion velocity becomes comparable to the thermal or random motions in the surrounding interstellar gas and the SNR gradually loses its identity. Knowing some initial parameters: energy and mass released by the SN explosion, the density of the surrounding medium and the magnetic field, the above simplified model can predict how the shock velocity, the density and the temperature behind the shock will evolve with time. These predictions must be compared with the available observations: in the optical, X-ray and radio range. Indeed the initial parameters are generally not known for an individual object, with the resulting difficulty that the classification of the object with respect to the four phases is not known precisely.

Expansion Ages

In our galaxy, less than 30 out of the 120 recognized radio SNR's have detected optical counterparts. Only a few of them exhibit the "classical" regular shell structure. However, this is not surprising because very *young* or very *old* remnants would only show a few thin filaments or a rather diffuse structure, like Cas A or Monoceros SNR, respectively, and also because a regular shell can only be formed by propagation in a homogeneous surrounding interstellar medium. In the case of very young remnants, when the velocity of the filaments is still very high, the combination of radial velocity and proper motion measurements can yield the distance of the object and its age with the assumption of uniform expansion. As an example, the optical filaments in Cas A, consisting of fast-moving knots (up to 9,000 km/s) and quasi-stationary filaments, have yielded an age of only 300 years (from the fast-moving knots), although this "historical" supernova was in fact not observed in the 17th century (but the measured extinction of 4.3 magnitudes in that direction could explain why). The quasi-stationary filaments have given an age of 11,000 years, therefore pointing towards a milder release of this material. For the Cygnus Loop, with measured radial velocities of the order of 100 km/s only, one gets an age of 60,000 to 100,000 years.

Abundance Determinations

However, the major interest of the optical filaments in SNR's is the possibility of making a detailed spectral analysis with particular emphasis on abundance determinations. The spectrum consists generally of emission lines of the most abundant atomic species in various ionization stages: H, He, N, O, S, Ne, as in other gaseous nebulae, with little or no detected continuum. But the major difference from the spectra of H II regions or planetary nebulae, although not recognizable in a straightforward way, is that in SNR's the elements are ionized by collisions (an effect of the shock-wave) while in the other nebulae the ionization is due to absorption of radiation from the central star(s). This must be taken into account when doing the abundance determinations. The abundance of a given *ion* can be derived in a straightforward way with respect to, say, hydrogen, by measuring the corresponding relative line intensities (for example the relative abundance of O^{++} to H^{+} comes directly from the intensity ratios of the 5007 [O III] line to $H\beta$) if the electronic temperature and density are known (from specific line intensity ratios).

But to go from this to the relative abundance of the *atomic* species requires the knowledge of how much of the oxygen, in our example, is in other forms than O^{++} (O^{0}, O^{+} or higher ionization stages), that is, to know the complete ionization structure. While this is generally done by model calculations trying to reproduce the observed spectrum in the case of H II regions, very few such models have been done yet for SNR's. However, these few models, by reproducing more or less correctly the observed spectrum of for instance the Cygnus Loop, have at least proven the validity of the hypothesis: ionization by collision and *not* (or only in a small fraction) by radiation. Furthermore, these complicated models (one has to solve simultaneously the hydrodynamical equations for the propagation of the shock-wave and the cooling equations) have shown that the temperature in the emitting region must be lower than in H II regions or planetary nebulae. This is confirmed by the observation of lines of low-ionization species like O I, S II or Ca II which are much fainter in other gaseous nebulae. This can then be used as a criterion to distinguish SNR's from other objects (see Fig. 1).

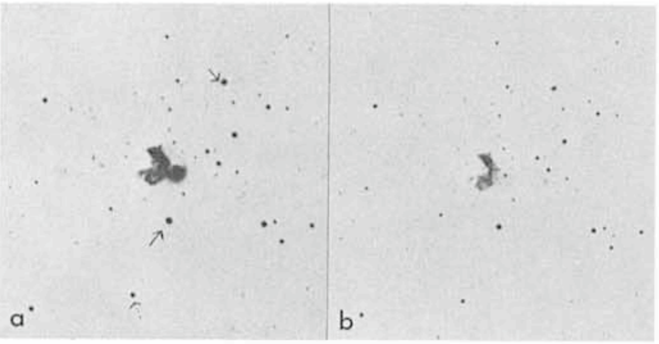


Fig. 1. — *Two plates taken by Dr. Barry Lasker with the CTIO 4 m telescope of N 63 A in LMC. Fig. 2a is an Hα picture, while Fig. 2b is taken through a [S II] filter, a characteristic emission of SNR's. The SW part, not appearing in [S II], is probably an ordinary H II region.*

Waiting for more model calculations, we may proceed with abundance determinations as long as we see lines of different ionization stages of the same element in the spectrum (a typical example is oxygen, for which we have [O I], [O II], [O III] lines), making possible an empirical estimate of the ionization equilibrium. In this way, for example, the fast-moving knots in Cas A show an overabundance of O and S by more than 50 (in mass) over the cosmic values, clearly demonstrating that we see material which has been processed in the core of a massive star. The overabundance of the "Si group" elements (Si to Ca) shows that O-burning has probably taken place and that the star must have been rather heavy, at least 20 solar masses ($M_\odot$). On the other hand, the quasi-stationary filaments in Cas A are overabundant in nitrogen by a factor of 10 with respect to hydrogen, while very little H is present in the fast-moving knots. This shows that we see here material having been processed via the C, N, O cycle and which was released through mass loss in the presupernova star (some 11,000 years before the SN explosion). This is consistent with the time elapsed between core C burning and core collapse and requires also a star of about 20 $M_\odot$.

Young SNR's are therefore a direct check of massive star evolution models. With older remnants, where substantial mixing with the interstellar medium has occurred, the abundance analysis would refer to this material only. A striking example is given by the SNR's in the Magellanic Clouds, where we find an underabundance of nitrogen with respect to hydrogen (compared to Orion) of a factor of 4 in LMC and 10 in SMC, fully consistent with results from H II regions and planetary nebulae. Similarly, the recently discovered SNR's in M 33 yield an underabundance of a factor of 2 in N; the same is found in nearby H II regions. We are therefore directly testing here how the interstellar medium has been enriched by processing to several generations of stars. The only young extragalactic SNR known up to now is N 132 D in LMC (see *Messenger* No. 5) which effectively shows a large overabundance of oxygen, making it a case very similar to Cas A. Abundance analysis will probably be extended in the near future to species not observable in the visible range of the spectrum, like carbon, by going to the near IR and to the UV with the new facilities now available.

X-ray Observations

The extension of the investigation of SNR's to the X-ray range has already greatly improved our understanding of their evolution. There are now 7 certain identifications of SNR's in X-rays in our galaxy, and some 10 possible or probable. Only one is possibly identified with an extended X-ray source in LMC, but needing confirmation. In general, the younger the remnant, the harder are the X-rays when detected. The observed spectrum is always compatible with a thermal origin. While there could still be some hesitations between thermal spectrum and power-law spectrum because of the uncertainties in the data, the detection, in some cases, of a Si XIV line in X-ray or a Fe XIV line in the visible strengthens the hypothesis of thermal bremsstrahlung, originating in the hot plasma behind the shock-wave. The derived temperatures are of the order of a few million degrees. As the X-ray luminosity is a well-known function of temperature and density of the emitting plasma, the measured absolute flux gives immediately the density (if the size is known). These values can then be inserted in the equations derived from the above model to get the inital energy and the age of the remnant. The mean value of initial energy is found to be $5 \cdot 10^{51}$ ergs for a surrounding density of 1 cm^{-3}, compatible with what is derived from the luminosity of supernovae.

But the surprising fact is that the derived ages are, for the older remnants, much shorter than those derived from the observed velocities in the filaments. This leads to the realization that the optical filaments we observe are probably not representative of the shocks as a whole, but are just those parts having encountered a higher-than-average density in the surrounding medium. For instance, the "X-ray" age of the Cygnus Loop is about 20,000 years (instead of 60,000 or more as derived from the optical filaments), which would still put it in phase 2 and not in phase 3. One therefore wonders whether a given phase can at all be ascribed to a whole remnant: certain parts, having been more decelerated than others, may already be in the radiative phase, while others, as demonstrated by the high temperature X-rays, are probably still in the adiabatic one. Indeed, new attempts to detect fainter filaments in the Cygnus Loop have revealed their existence with velocities two to three times higher than the previously known strong filaments. These problems of inhomogeneity are now being introduced into the models, together with the effects of inward-propagating shocks resulting from the interactions of the initial blast-wave with the surrounding medium. That such complicated phenomena do indeed occur is shown by the illustration (Fig. 2).

Radio Observations

The origin of the non-thermal synchrotron radio emission from SNR's, while being the first criterion for identification of a SNR, is still not understood. A large effort has been made in mapping the sources, showing that the radio shells in general are more complete and uniform than the optical patches and that the superposition with optical features is normally very good. Polarization maps show the magnetic field to be orientated radially in the young remnants (Cas A, SN 1006, Tycho) and tangentially in the older ones (Cygnus, W 44). This is consistent with the idea that the shock-wave plays a role in compressing the magnetic field: but *which* fraction is inherent to the SNR, *which* fraction is compressed interstellar magnetic field, and *where* are the high energy electrons coming from, are still unanswered questions.

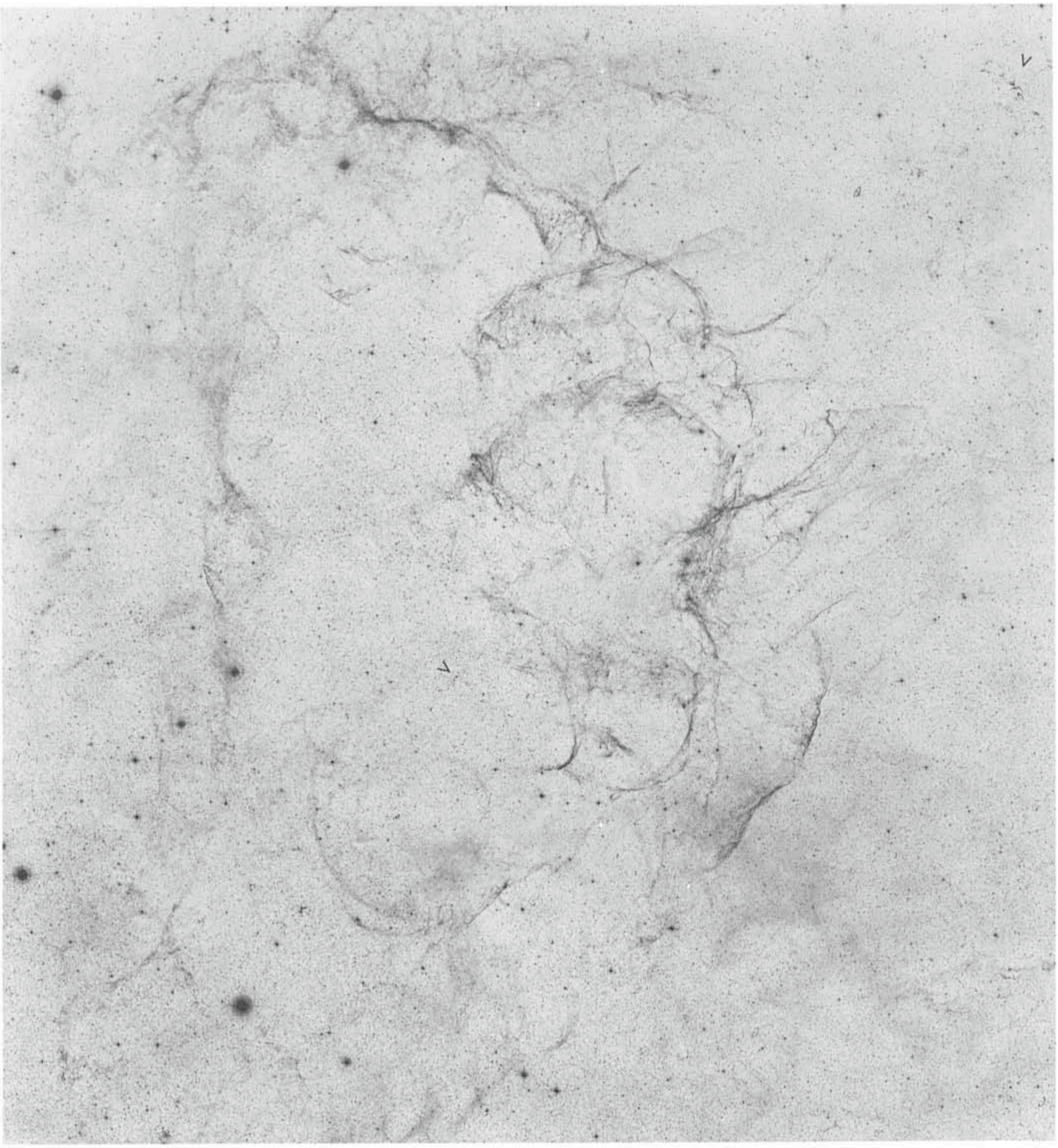


Fig. 2. — *A 90-min red plate, 098-04 + RG 630, taken with the ESO Schmidt telescope by H.-E. Schuster, of the Vela Supernova Remnant. It shows the complex structure resulting from interaction of a shock-wave with an inhomogeneous interstellar medium. The age is estimated to be about 12,000 years. The central arrow shows the approximate location of the Vela pulsar. The arrow in the NW corner shows the Puppis SNR, which exhibits strong [N II] lines. Did it explode in an already enriched surrounding medium?*

The Frequency of SN's

However, if the individual radio evolution is not yet completely understood, the large number of known radio SNR's in our galaxy provides a statistically significant sample to estimate the mean interval between SN explosions. The linear diameter of SNR's can be estimated from the empirical relation between radio surface-brightness and diameter, calibrated by some remnants with well-determined distances. Then the histogram of diameters can be used, either with some age calibrators or by trying to fit it to the theoretical evolution curve, to determine the frequency of SN events. One finds a mean interval of 75 to 150 years, depending on the assumed completeness of the catalogues. This has to be compared with a mean interval of 11 years found from historical SN's (however with large correction factors (or 10 to 30 years found from statistics of SN's in external galaxies, depending on the type, Sbc or Sb, that is attributed to our galaxy.

Clearly, the discrepancy is large enough to look for other factors. It should, however, be stressed that a mean interval of 10 years would imply that stars more massive than 3 $M_\odot$

should explode as SN's, while 75 years would give a lower limit of 9 M☉, all compatible, within the errors, with the ideas about massive star evolution. No additional constraints can be set up from pulsar birth-rates, because of the large uncertainty in the evaluation of the maximum age of a detectable pulsar. This age is at least a factor of ten higher than the assumed maximum age for a detectable SNR (approximately 10^5 years) and is probably enough to explain why, if about 300 pulsars are now detected, only two firm associations between pulsars and SNR's have been made: the Crab and Vela, both young objects. The detection of such associations is in addition made difficult by the large transverse velocities now measured for some pulsars.

The same kind of comparison between SNR statistics and massive star evolution has been tried recently for LMC. Owing to the large uncertainties involved there: uncompleteness of the SNR sample and no firm independent knowledge of what the SN rate should be, one can only conclude that the number of observed supergiants compared to the best estimates of the SN rate is compatible with the idea that the minimum mass for a SN progenitor lies somewhere between 4 and 8 M☉. But, both in LMC and in our galaxy, it remains to be explained why so few SNR's of diameters larger than about 30 pc are observed, while this corresponds, according to the present views, to only about one-tenth of the expected life time. As most of the SNR's are detected at radio wavelength, a better understanding of the relations between the radio emission and the surrounding medium may help to solve that aspect of the problem.

Further Research Needed

Not very much attention has been given in this review to the Crab Nebula. It reflects, in fact, the work on SNR's in the last years, where the Crab was believed to be understood, at least as far as the mechanism of excitation of the visible filaments was concerned, and also regarded as being too peculiar by comparison with other SNR's. However, things are changing now. A search is under way for fainter filaments outside the main nebula which may be the tracers of the shock-front and some new possible members of the same morphological class as the Crab are being found (3C 58, G21.5-0.9). Other trends of present research include the search for older, large-size SNR's in our galaxy and LMC, with the difficulty of distinguishing them from H II regions or other shock-excited nebulae (stellar winds); detailed investigation of velocity structures to be compared with models; extension of the studied spectral range to the UV and near IR; search for SNR's in other galaxies of the Local Group mainly by optical techniques (see Fig. 1), and last, but not least, investigation of nuclei of external galaxies showing the characteristic emission lines of low ionization species, in order to see whether or not there is any significant contribution of shocks in the excitation of these nuclei. There is great hope that, with the simultaneous development of model calculations, all this effort will eventually answer the remaining major questions about SNR's and their progenitors. And we may at the same time learn as much about the surrounding interstellar medium as about heavy element processing in massive stars.

A New Infrared Top-end for the 3.6 m Telescope

So far, most, but not all, infrared observations have been carried out with conventional optical telescopes. This often implies that a comparatively strong infrared radiation (heat) from the telescope proper has to be subtracted from the total signal for a given celestial infrared source. This is particularly so when the telescope has much material in the beam, e. g. support of the secondary mirror, cables, etc.

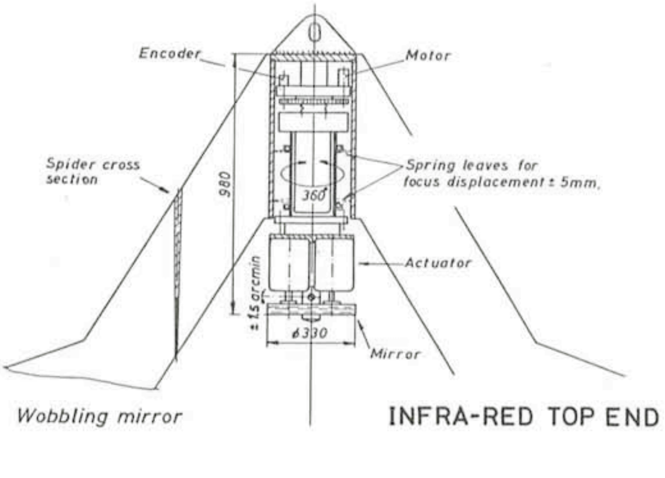
This problem was taken into account when the 3.6 m telescope was designed. It has interchangeable top-units, each specifically built for its purpose. ESO engineers Wolfgang Richter and Rolf Grip have now started designing the new infrared top-unit. This is a brief status report about that project:

The infrared top-end for the 3.6 m telescope is composed of two units:

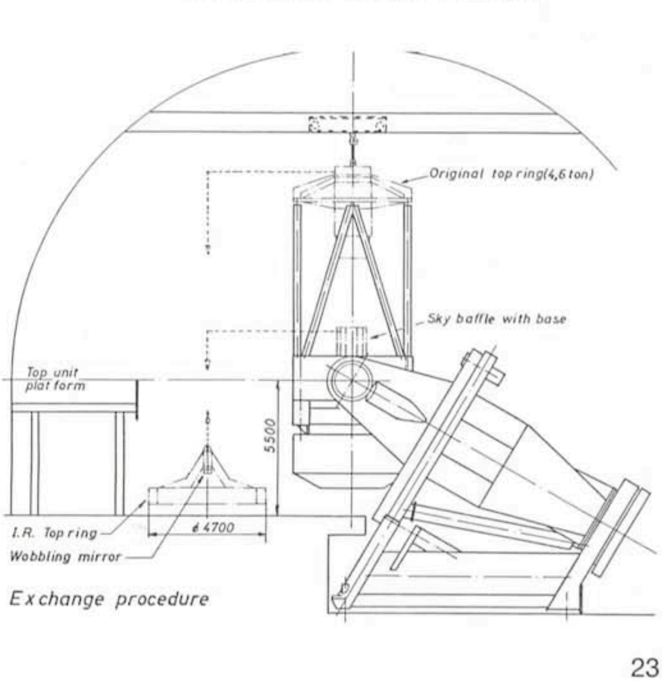
– wobbling secondary mirror
– top-ring for infrared observation.

The design of these two units is actually in progress. The optical conception is a secondary mirror for an f/35 at the Cassegrain focus. This secondary mirror will be excited by two electromagnetic actuators, one pushing, the other pulling, and vice-versa.

This wobbling unit can be rotated around the optical axis to allow a free choice of the wobble-direction.



Wobbling mirror INFRA-RED TOP END



Exchange procedure

A new top-ring for the telescope is required to remove the material, which supports the normal top-units, out of the light beam. The outer ring is therefore heavier in order to maintain the balance of the telescope tube.

The control system of the wobbling mirror is still under study.

ALGUNOS RESUMENES

El cercano encuentro con 1978 CA y 1978 DA

Recientemente el Dr. Hans-Emil Schuster ha descubierto dos planetas menores que se estaban acercando a la tierra sobre placas que fueron tomadas con el telescopio Schmidt de ESO en La Silla.

El primer planeta (1978 CA) fue descubierto como una pálida raya sobre una placa tomada en la noche del 7 al 8 de febrero. Durante las noches siguientes se tomaron algunas placas de exposición corta y se estableció una órbita preliminar que confirmó la cercanía del nuevo planeta menor a la tierra (42 millones de kilómetros el día 8 de febrero).

Hans Schuster notó una segunda raya larga en otra placa tomada para el 1978 CA el día 17 de febrero. Se tomaron más placas de este objeto y una semana más tarde se confirmó que 1978 DA (como fue llamado el segundo planeta menor) también se acercaría bastante a la tierra.

Trabajando en directa colaboración con el Dr. B. Marsden del Observatorio Smithsonian en Cambridge, Massachusetts, fue posible establecer la órbita *antes* de producirse las aproximaciones más cercanas durante marzo de 1978. Esto permitió que otros observadores pudieran estudiar los pequeños planetas y conocer más sobre sus propiedades físicas.

El Dr. Degewij del Observatorio Lunar y Planetario de la Universidad de Arizona es uno de los astrónomos que han observado los planetas. Nos informa que los diámetros de los objetos son de aproximadamente 1,86 km para 1978 CA, y 0,9 km para 1978 DA.

La Gran Nube Magallánica en luz infraroja!

En el Observatorio Europeo Austral se está haciendo muchas placas de las Nubes Magallánicas con el telescopio Schmidt de 1 metro. En la página 19 mostramos La Gran Nube vista en luz infraroja en una placa obtenida el día 16 de enero de 1978. El tiempo de exposición fue de una hora. La placa fue sensibilizada y guiada por Guido Pizarro y su uniformidad es notable. Normalmente es muy difícil hipersensibilizar placas infrarojas sin correr es riesgo de obtener grandes desuniformidades.

La placa muestra especialmente las estrellas más rojas en la Gran Nube Magallánica y suprime la nebulosa gaseosa. Incluso en la parte céntrica de la barra se ven las estrellas bien resolvidas. La nebulosa en la parte superior izquierda es 30 Doradus, la región H II más brillante de la Gran Nube Magallánica.

Radio observaciones del cometa Bradfield (1978c)

La ventaja de radio observaciones de onda larga reside en la calidad de los espectros que no es afectada ni por las condiciones atmosféricas ni por la proximidad del sol o de la luna. Sin embargo, la mayor desventaja en la radio observación de cometas se encuentra en la debilidad de las señales que requieren largos tiempos de integración, y es importante que las coordenadas se conozcan con gran precisión.

Los Drs. Despois, Gerard, Crovisier y Kazès del Departamento de Radioastronomía del Observatorio de Meudon en Francia han ya observado muchos cometas con el radio telescopio francés de Nançay. Al saber que un nuevo cometa brillante, Bradfield (1978c), avanzaba hacia el norte, decidieron estudiarlo inmediatamente. Sin embargo, debieron interrumpir las observaciones por falta de recientes posiciones exactas.

A pedido de ellos, el Dr. Hans-Emil Schuster fotografió exitosamente el cometa con el telescopio Schmidt de ESO y el Dr. Marsden en Estados Unidos pudo computar una mejor efemérides. Con esta nueva efemérides fue posible reasumir las radio observaciones.

Este suceso no es sólo un ejemplo para la importancia de la colaboración internacional en la astronomía, sino también para la colaboración entre la radioastronomía y la astronomía óptica.

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 nine 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.

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