THE MESSENGER

EL MENSAJERO

No. 12—March 1978

La Silla Anno 19xx?

The ESO Conference on Optical Telescopes of the Future (p. 2) showed a clear division between the astronomers who want very large telescopes (16 to 25 m class) and those who opt for an array of interlinked "small" telescopes (~100 elements, each 2–3 m mirror diameter). Confronted with the continuously increasing demand for precious telescope time on La Silla (p.16), we here present the "optimal-solution plan" for La Silla that recently leaked from the ultra-secret ESO Planning Group (not even the Finance Committee knows about it!). Drawn by Karen Humby of the Engineering Group in Geneva, this beautifully simple conception purportedly aims at the definitive pacification of the various advocates of future telescopes by a masterful combination of size and quantity. It is reported, however, that fears have been expressed about the long-term stability of the support . . . no, you are wrong, of the La Silla bedrock, of course.

ESO Conference on Optical Telescopes of the Future

This conference took place in Geneva between 12 and 15 December 1977.

The time seemed ripe for a conference on this subject, for many ideas are in the air and certain projects in the United States which deviate markedly from the conventional telescope are already completed or in active study.

The conference opened with a review of the astronomical case for large telescopes, an overview of the technological possibilities and the possibilities from space.

A session followed on conventional large telescopes in which technical aspects of a number of existing large telescopes and the possible extension of conventional telescopes to larger sizes were presented.

The following day was devoted entirely to Incoherent Arrays and Multi-Mirror Telescopes. In the sense that most effort deviating from the conventional large telescope has so far gone in this direction, the neutral observer had the feeling that this represented the centre of gravity of the conference. A wide variety of interesting solutions were presented with a collecting area up to the equivalent of a 25 m telescope and arrays with up to 100 telescopes.

A session on special techniques fitting into no clear group was followed by sessions on Coherent Arrays and Interferometers. This gave a broad review of current techniques and future possibilities and a comparison of optical and radio techniques.

The last morning of the conference, concerned with image processing and live optics, showed clearly the tremendous gain to be obtained in overcoming the effects of seeing even without increase in instrumental size. A clear distinction emerged at this conference between the terms "active optics" and "active structure". The latter implies, for example, the active control of tilt or position of several mirrors to combine images; the former the control of the form of, say, a thin mirror. The importance of both possibilities became increasingly clear throughout the conference.

The final session included a review of trends in detector developments. (Detectors were considered too vast a subject to be dealt with in detail but an overview was necessary to underline the essentially complementary nature of progress in telescope design and detectors.) The rest of the session was devoted to a review of the astronomical implications of the contributions and discussions, followed by a panel discussion. The latter developed into a most lively general discussion with numerous participants representing very many (often healthily conflicting!) viewpoints. While the consensus viewpoint seemed to support the view that the emphasis for post-conventional telescopes should lie in the incoherent addition of more photons from bigger systems, a strongly vocal minority was clearly convinced that techniques using phase information should not be neglected. The discussion also inevitably brought up the vexed question of how an astronomer should or would like (not necessarily the same thing) to work with future instruments—the visit to the CERN installations had provoked considerable thought on this subject!

Thus ended a conference which seemed to have largely fulfilled its purpose: to encourage the debate on how instrumental funds in the future should be spent to best effect. The organizers thank all participants for making it such a stimulating event. Our thanks are due particularly to all the speakers who have enabled us to produce a virtually complete volume of Proceedings within two months of the Conference—see the notice.

R.N. Wilson

Proceedings of Conference Optical Telescopes of the Future

The Proceedings of this conference which contain nearly all the papers presented and the essential part of the discussions are now available.

Please send your order together with a cheque payable to ESO for Sfr. 40.– (price of copy including postage) to:

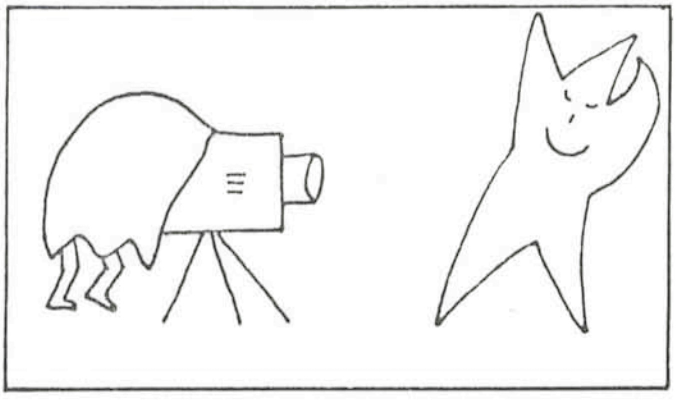
European Southern Observatory
c/o CERN
Attn. Miss M. Carvalho
CH-1211 Geneva 23

Forthcoming ESO Workshops

Two ESO workshops have been planned during 1978 on the subjects of astronomical photography and infrared astronomy. As in the case of earlier ESO workshops, attendance is limited and by invitation only.

"Modern Techniques in Astronomical Photography"

This workshop will take place in Geneva on the CERN premises during May 16–18, 1978. About 50 participants are expected, mostly from European countries, but also from North and South America and Asia. The two principal subjects to be discussed are sensitization and calibration of photographic plates. There will also be a discussion about the copying of plates and use of colour photography in astronomy. Several participants will talk about the photographic work at their observatories and a number of new techniques will be reported.



The proceedings will appear shortly after the conference. Further information may be obtained from R.M. West, ESO, c/o CERN, CH–1211 Geneva 23, Switzerland.

"Infrared Astronomy"

By invitation of the Stockholm Observatory, the ESO workshop on infrared astronomy will be held on the island of Utö on June 20–22, 1978. About 40 European astronomers active in infrared astronomy will be invited in order to discuss the scientific framework, the research planning and the instrumental development which ESO should foster in this area.

The programme of the workshop includes:

- Review talks on astrophysical problems where infrared observations are of particular value,
- Review talks on the present status of various instrumental techniques in the field of IR spectroscopy and photometry,
- Reports on IR space project and on other European plans.

More detailed information may be obtained from P. Salinari, ESO, c/o CERN, CH–1211 Geneva 23, Switzerland.

The ESO Council

The ESO Council held its 31st meeting in Munich on December 1, 1977. The present members of the Council are:

Belgium:	M. Deloz
	P. Ledoux
	L. Poulaert
Denmark:	K. Gyldenkerne
	P. A. Koch
	B. Strömgren
France:	J.-F. Denisse (Chairman)
	S. Filliol
Fed. Rep. of Germany:	I. Appenzeller
	C. Zelle
The Netherlands:	B. Okkerse
	H. G. van Bueren
Sweden:	M. Fehrm
	P. O. Lindblad

The Sculptor Dwarf Spheroidal Galaxy

S. van Agt

The first visiting astronomer to use the 3.6 m telescope in October 1977 was Dr. Steven van Agt from the Astronomical Institute of the Nijmegen University, the Netherlands. At that time the object for his study, the Sculptor dwarf galaxy, passed close to the zenith of La Silla at midnight. He obtained prime-focus photographic plates for the study of variable stars in this nearby galaxy. A very large reduction work is connected with this kind of astronomical research, and it is therefore not yet possible to give detailed results, but Dr. van Agt here discusses the reasons for investigating the Sculptor dwarf galaxy.

Forty years ago Harlow Shapley announced in the Harvard Bulletin No. 908 the exciting discovery of "A Stellar System of a New Type" in Sculptor. The new system showed up as an assembly of hazy images on an exposure with the 24-inch Bruce telescope of the Boyden station in South Africa. The first confirmation of the reality of the object came from a plate obtained by S. I. Bailey in 1908, on which a faint patch of light was seen at the position of the Sculptur system. Bailey obtained this plate during a site-testing expedition with a 1-inch telescope and a total exposure over five nights of 23^h16^m! Additional observations with the 60-inch telescope resolved the individual stars and ruled out the possibility that the Sculptor system could be an extended cluster of galaxies.

Dwarf spheroidal galaxies are generally known by the name of the constellation in which they appear. Within approximately 250 kpc, seven Sculptor-type systems are now known including the recently-discovered dwarf in Carina. In addition, three dwarf spheroidal galaxies have been discovered by S. van den Bergh close to the Andromeda nebula. Within the Local Group there are now ten Sculptor-type systems known. Since these objects are difficult to detect behind the stellar foreground of our Galaxy it is not likely that this number is free from selection effects.

At the time of the first discovery the interest of astronomers was focussed strongly on the significance of the shapes of galaxies. Nowadays the dwarf spheroidal galaxies, and especially the nearest, offer a unique possibility to study the evolution of isolated stellar agglomerates.

The low surface density of the stars permits inspection of the individual stars, also in the centre region of the systems. It gives a unique possibility to trace, in a complete survey, all the variables, of which there are many, through the whole system.

The Sculptor dwarf spheroidal galaxy is located at a distance of 78 kpc (250,000 light-years). This is derived from a mean, apparent luminosity of 20.13 magnitude in B for the RR-Lyrae variable stars. On the sky the Sculptor system has a considerable size. The more than 600 variables which have now been discovered cover an elliptical area with a major axis of about two degrees, corresponding to a linear dimension of 2.7 kpc. The positions and identifications of the variables are now in press (Publ. of the David Dunlap Observatory).

New photographic observations have been obtained by the author at the prime focus of the ESO 3.6 metre telescope at La Silla in October 1977. The IIa-O plates reach beyond magnitude 21.5 in 40 minutes. The aim of the programme is the determination of the periods and the luminosities for a selection of the variables in the 16 arcminute field of the 3.6 metre telescope. The field on which the plates are exposed in this part of the programme contains a photoelectric sequence as well as a secondary photographic standard sequence.

At present the plates are being reduced at the Department of Astronomy of the University at Nijmegen, where a semi-automatic iris-photometer and a unique projecting Blink-comparator are available.

Although many characteristics of the stars in dwarf spheroidal galaxies are very similar to those of the stars in globular clusters, there are also significant differences. One is the occurrence of bright cepheids which do not follow the Period-Luminosity relation of population II cepheids. In the

Fig. 1. — *The Sculptor Dwarf Spheroidal Galaxy reproduced from ESO Quick Blue Atlas plate No. 1737 of field 351, obtained on November 17, 1976. Exposure time 60 min on IIa-O behind a GG 385 filter. North is up and east to the left. ESO 1 m Schmidt telescope.*

Sculptor system and in other dwarf spheroidal galaxies these anomalous, so-called BL Her stars are brighter than the cepheids in galactic globular clusters by approximately 0.5 to 1.0 magnitude at the same period. Similar anomalous BL Her stars are likely to be present in the Small Magellanic Cloud.

It has been suggested that these stars belong to a younger population than the majority of stars in the same dwarf galaxy. In this hypothesis the galaxy itself was formed independently after the collapse of our Galaxy.

If higher masses are assumed for the anomalous BL Her stars, another hypothesis put forward to explain the existence of these stars is that mass-transfer is taking place within binary systems. The observational evidence, however, is not sufficient and in general the knowledge about the stellar content and more specifically about the numerous variable stars is still incomplete (cf. the review papers: Agt, S. L. Th. J. van, 1973, Variable Stars in Globular Clusters and in Related Systems, ed. J. D. Fernie (Dordrecht, Holland), p. 35; Bergh, S. van den, 1968, J. Roy. Astr. Soc. Canada, **62,** 1, and 1975, Ann. Rev. Astro. Ap. **13,** 217; Hodge, P., 1971, Ann. Rev. Astron. Ap., **9,** 35).

Fig. 2. — *A small part of the Sculptor galaxy, reproduced from a 3.6 m plate. Same orientation as in figure 1. Note the higher resolution. The seeing was mediocre and the limiting magnitude is 0.5 to 1.0 deeper than the Schmidt plate. This, however, is not important for photometric measurements, where the* integrated *density of the images is measured.*

Quasars and BL Lac Objects as Active Nuclei of Giant Galaxies

J. Bergeron

Are we beginning to understand the nature of the quasars and the equally mysterious BL Lacertae objects? Are they nothing but extraordinarily bright galaxy nuclei? Dr. Jacqueline Bergeron, now with the ESO Scientific Group in Geneva, summarizes the most recent findings in this exciting field.

The observed similarity and continuity between the active nuclei of Seyfert type I, broad-line radio galaxies and quasars began to be fully exploited only around five years ago. The possibility of intrinsically similar physical processes in both types of objects was raised earlier, but the basic idea of quasars and BL Lac objects as very powerful nuclei of large galaxies is only a recent one and not yet entirely accepted.

The similarity between the Seyfert type I galaxies and the quasars are (i) in their optical line spectra characterized by very broad allowed lines (typical velocities of (0.5–1.5) $\times 10^4$ km sec^{-1}) variable on a time-scale of months, and narrower forbidden lines with a large range of ionization stages, and (ii) in their variability at optical frequencies on a time-scale of weeks. The radio sources are also found to be very variable. The BL Lac objects have a featureless optical continuum spectrum (yet in some cases very weak emission lines have been detected) and they are characterized by an extreme variability at radio frequencies, down to time scales of days.

The current definition of quasars (which also applies to BL Lac objects) is that they have star-like images on direct plates. Yet nebulosities or "fuzz" associated with quasars were known since the beginning of quasar research, i. e. around TON 256 and 3C 48, and were the subject of discussion and puzzlement. In particular the large extent of 100 kpc (for $H_0 = 50$ km Mpc^{-1}sec^{-1}) for the nebulosity accompanying 3C 48 illustrated in the Figure did not suggest a normal galaxy.

A photographic programme was undertaken by J. Kristian to attempt to detect underlying galaxies centered on quasars. The quasars are so bright that their light could swamp that of the underlying galaxy. Thus the latter could be detected only for quasars of small redshift and if its image size is greater than that of the quasar. These observations were consistent with the hypothesis of quasars as active nuclei in galaxies. Indeed those quasars which were predicted to show underlying galaxies did so and those which were predicted not to show underlying galaxies did not, with the exception of 3C 48.

However, photometric studies of faint envelopes of galaxies, also in progress in the early 1970's confirmed the existence of *large* envelopes. Both elliptical and spiral galaxies were found to be surrounded by large envelopes, $\gtrsim 100$ kpc for elliptical galaxies and not significantly smaller (by a factor of 2) for spiral galaxies (when compared at same integrated luminosities).

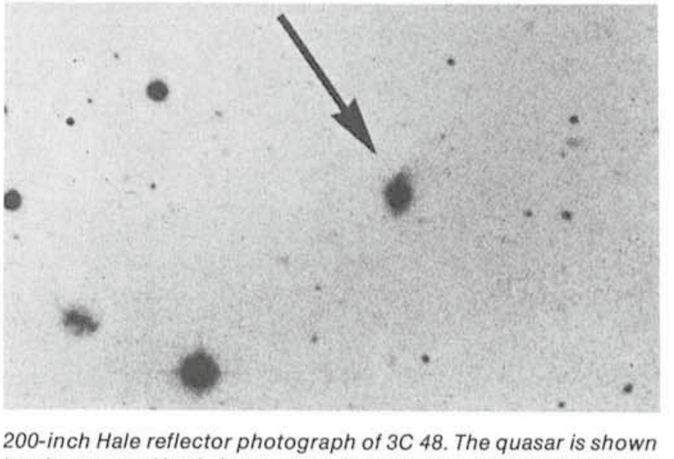
Further one must emphasize that less attention was devoted to Seyfert galaxies than to quasars before 1968. Few "extreme Seyfert galaxies" of redshift above 0.01 were studied then. Some extreme Seyfert-type galaxies at redshift close to 0.05 were observed by W.L.W. Sargent among the objects in the Zwicky lists. All these active nuclei were indeed surrounded by nebulosities. Yet for most of them, a galaxy of stars and cold interstellar gas was not brought into evidence.

The next step necessary to definitively solve the problem of underlying galaxies required spectroscopic observations of these nebulosities.

Recently, such observations have revealed two types of nebulosities: (i) those dominated by a strong emission-line spectrum, and no detection of an intrinsic continuum (typically 3C 48), (ii) those characterized by a spectral enery distribution and absorption lines consistent with that of a normal galaxy of stars (typically BL Lacertae). In all cases, the redshift for this nebulosity is very close to that of the active nucleus. This appears to rule out gravitational redshifts for quasars.

Spectroscopic observations of the nebulosity around the quasar 3C 48 were reported in 1975. Other quasars, and also the Seyfert galaxy 3C 120 were studied and their nebulosities exhibit the same type of strong emission-line spectrum. The two more intense optical lines are [O II] λ 3727 and [O III] λ 4959, 5007; [O III] is stronger than [O II] and much stronger than Hβ, with in some cases [O III]/Hβ as high as 20. This type of spectrum is unusual for a galaxy. It cannot be accounted for by H II regions heated by main-sequence stars, whatever the abundances of heavy elements. Hard UV or collisional heating is required. The hard radiation, $\gtrsim 50$ eV, emerging from the active nucleus is a possible energy source for the nebulosity. The observed line spectrum could then be achieved if the gas density is low, from 0.03 to 3 cm^{-3}. At a cosmological distance the nebulosity is then similar in dimensions and mass to the extended neutral H disks around spiral galaxies. Other possible models involve denser gas, thus very clumpy material, i. e. dense filaments, heated by the emerging UV radiation from the active nucleus.

A strong controversy about spectroscopic observations of the nebulosity associated with BL Lacertae took place in 1974–75. The intrinsic continuum spectra of such nebulosities are very difficult to observe, due to their weakness and to the strong contamination of nucleus light in the observed annular apertures. The detection of typical absorption features, such as Ca II K and Mg I is a crucial point. At least



200-inch Hale reflector photograph of 3C 48. The quasar is shown by the arrow. North is up, west is right. The field is 3' EW and 2'30'' NS.

two such detections have been made: for BL Lacertae and for the quasar PHL 1070. In both cases the extended light surrounding the active nucleus is consistent with a luminous galaxy of stars. There is a large number of nebulosities for which only a featureless continuum spectrum has been detected. The magnitude of the nebulosity is then consistent with that of a large galaxy.

Quasars and BL Lac type objects can now be more firmly identified as active nuclei of giant galaxies. For BL Lac type objects and some quasars, the surrounding nebulosity is entirely consistent with a giant elliptical galaxy. For quasars such as 3C 48, or Seyfert galaxies such as 3C 120, the nature of the "surrounding galaxy" is not as clear. The emission from the ionized gas is much larger than would be that of the stars and only a very high sensitivity would allow the detection of the intrinsic continuum and of absorption lines. Another possible approach, possible with present-day techniques for extreme Seyfert galaxies, would be the determination of a rotation curve within the nebulosity from the brighter emission lines.

CHIRON: A New Planet in the Solar System

Last October, Charles T. Kowal of the Hale Observatories in Pasadena, California, found a new planet in the solar system. Comparing two plates from the 48-inch Palomar Schmidt telescope in a blink microscope, he noticed a small trail of a moving 18th-magnitude object. From these plates and others which were obtained on the following nights, it soon became obvious that the new planet had an exceptionally slow motion. At opposition the motion of a planet is inversely proportional to the distance and a first estimate put 1977 UB (as it was designated) at about the distance of Uranus, almost 3,000 million kilometres away.

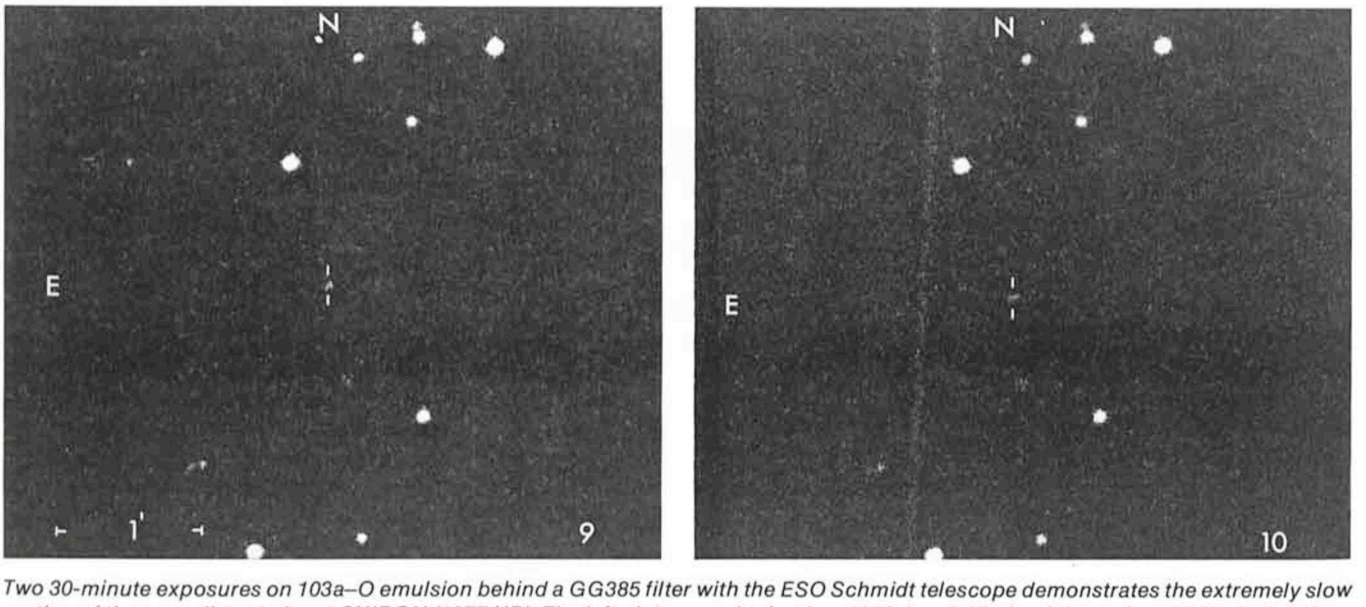
When more observations became available, it was possible for Dr. B. Marsden at the Smithsonian Observatory to confirm this distance and to establish the orbit. Extrapolating backwards, Mr. Kowal and Dr. W. Liller found 1977 UB on old plates in the Harvard plate library, obtained in 1895, 1941 and 1943. Some further observations from Palomar helped to improve the orbit, and it is now known that 1977 UB is a unique object in the solar system.

It moves in a rather elliptical orbit ($e = 0.38$) with perihel just inside the orbit of Saturn and aphel close to that of Uranus. It was actually discovered a few years after it had passed through the aphel and will become as bright as magnitude 14.5 in 1996 when it again reaches perihel. The orbital period is just over 50 years.

For the benefit of the eagle-eyed readers of the *Messenger,* we here show two plates of 1977 UB, obtained with the ESO Schmidt telescope on 1978 January 9.05209 and 10.04936 UT. The plates were exposed during 30 minutes rather low in the western sky, just after sunset. At that time the planet was nearly stationary, near its smallest right ascension. The seeing was bad, probably around 4–5 arcseconds on both occasions and the images are therefore somewhat fuzzy, in particular on the 10th.

But it does not move! exclaims the (slightly inattentive) reader. Sorry, it does. On the left hand photo (from the 9th) the position was $1^h 55^m 16^s.04$; $+11°08'21''.1$, and on the 10th $1^h 55^m 15^s.80$; $+11°08'16''.4$. This corresponds to a movement of only $3''.6$ to the west and $4''.7$ to the south (0.05 mm and 0.07 mm, respectively, on the original plate). You can see it if you measure the distances to the surrounding stars on the figures.

From the magnitude it can be estimated that 1977 UB has a diameter of a few hundred kilometres. It is most likely the first known member of a new class of asteroids outside the orbit of Jupiter, and Kowal has proposed the name CHIRON (a centaur in Greek mythology). There is, however, still the possibility that it is a comet; at very large distances, it can be very difficult to tell the difference, when no tail shows up and the "head" is perfectly stellar-like.



Two 30-minute exposures on 103a–O emulsion behind a GG385 filter with the ESO Schmidt telescope demonstrates the extremely slow motion of the new, distant planet CHIRON (1977 UB). The left plate was obtained on 1978 Jan. 9.05, the right on Jan. 10.05. At that time, the distance to CHIRON (from the Earth) was 2,623 million kilometres. The scale is indicated. The (near) N–S trail on the 10th is an artificial satellite.

Morphological Studies of the Large Magellanic Cloud on ESO Schmidt Plates

E. H. Geyer

This article, by Dr. Edward H. Geyer of Observatorium Hoher List, Fed. Rep. of Germany, touches upon a somewhat controversial subject in contemporary astronomy. The structure of the Large Magellanic Cloud is the focus of much research with southern telescopes. Originally classified "irregular", it now appears that it may be possible to break down the LMC into two components, a central ellipsoidal and a somewhat offset spiral structure. Dr. Geyer discusses the problems of identifying the various stellar components (the populations) in the LMC, by means of Schmidt plates from La Silla.

Schmidt telescopes are the most efficient information gathering instruments in optical astronomy. Besides the wide field (up to 10°) with nearly perfect image definition also at the field edges, the small focal ratio (normally f/1 to f/4) permits resolution-limited photographs to be obtained within tolerable exposure times, even on fine-grain emulsions.

These advantages are especially useful for the structural study of the Magellanic Clouds (MC). The author has received several ESO Schmidt plates in U-, B-, V-colours of the Large Magellanic Cloud (LMC), taken by H.-E. Schuster in 1973/74, and carries out different studies of the structure of this nearby galaxy and its stellar sub-aggregates.

One degree of arc on the sky corresponds to about 1 kpc at the distance of the LMC. Plate-resolution-limited faint stellar images taken with the f/3, F = 306 cm ESO Schmidt telescope have typically diameters of about 20μ, which is about 0.3 pc at the LMC's distance. This is the order of magnitude of the geometrical resolution of structural features in the LMC.

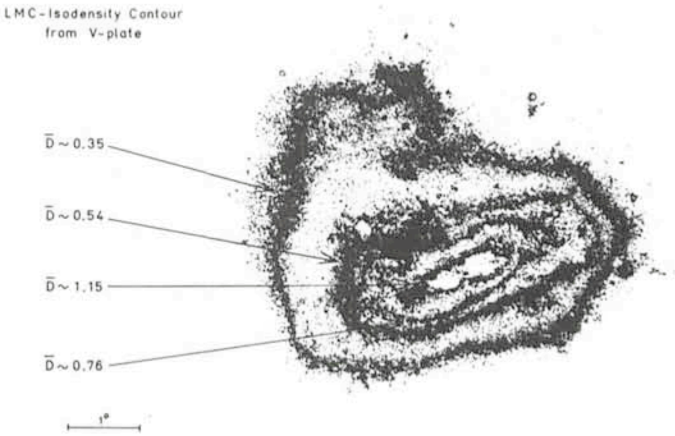
The Structure of the LMC

More than ten years ago, I derived the following picture of the overall structure of the LMC from colour composites of U-, B-, V-, R-photographs with the duplicate of the original Schmidt camera at the Boyden Observatory: it consists of two components, (a) an extended ellipsoidal galaxy, representing the old stellar population of the bar, and (b) an asymmetric and peculiar Sc-spiral, the centre of which seems to be near the 30 Doradus nebula complex. At least three spiral features can be traced, the most conspicuous one emanates from that centre, crosses the long side of the bar in north-west direction, and splits at its outer part. These spiral features have recently been rediscovered by Drs. Schmidt-Kaler and Isserstedt from a study of the distribution of typical spiral tracers like luminous blue stars and HII-regions.

A further possibility for a morphological study of the LMC is based on surface photometry, although in principle the interpretation is much more difficult, because integral values along the line of sight are observed. However, photographic isodensity contours from a single Schmidt plate give higher spatial resolution than what is obtained photoelectrically which moreover demands about one hundred times more observing time! Such isodensity contours have been obtained by the Agfa Contourfilm technique. By this simple method, which does not need complex isodensity tracing machines, photographic density differences of about 0.1 or less can easily be separated. Besides the sub-threshold stars (the limiting magnitude of the Boyden Schmidt telescope is $< 17^{m}$, and that of the ESO Schmidt telescope is $< 21^{m}.5$), the emission- and reflection-nebulae and the dark cloud areas in the LMC contribute significantly to the isodensity contours.

Isodensity Contours

In figure 1 are only shown the less chaotic composites of isodensity contours in the V spectral region, from which figure 2 was obtained by the suppression of smaller details. The outer contour also embraces the OB association of the Shapley constellation III. The brightest stars ($< 16^{m}.5$) are resolved and do not contribute to the contours. This means that the fainter stars (with $M_V > -2^{m}.5$) decisively contribute



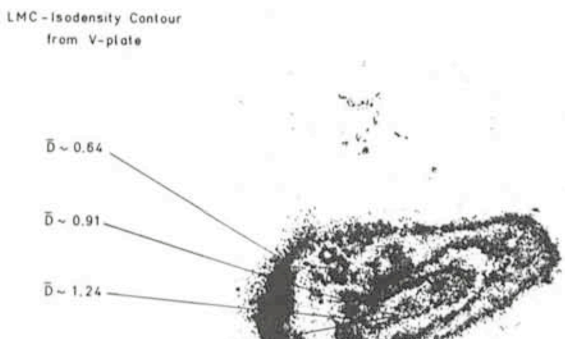


Fig. 1. — *Isodensity contours of the LMC in visual light, obtained by the Agfa Contourfilm technique.*

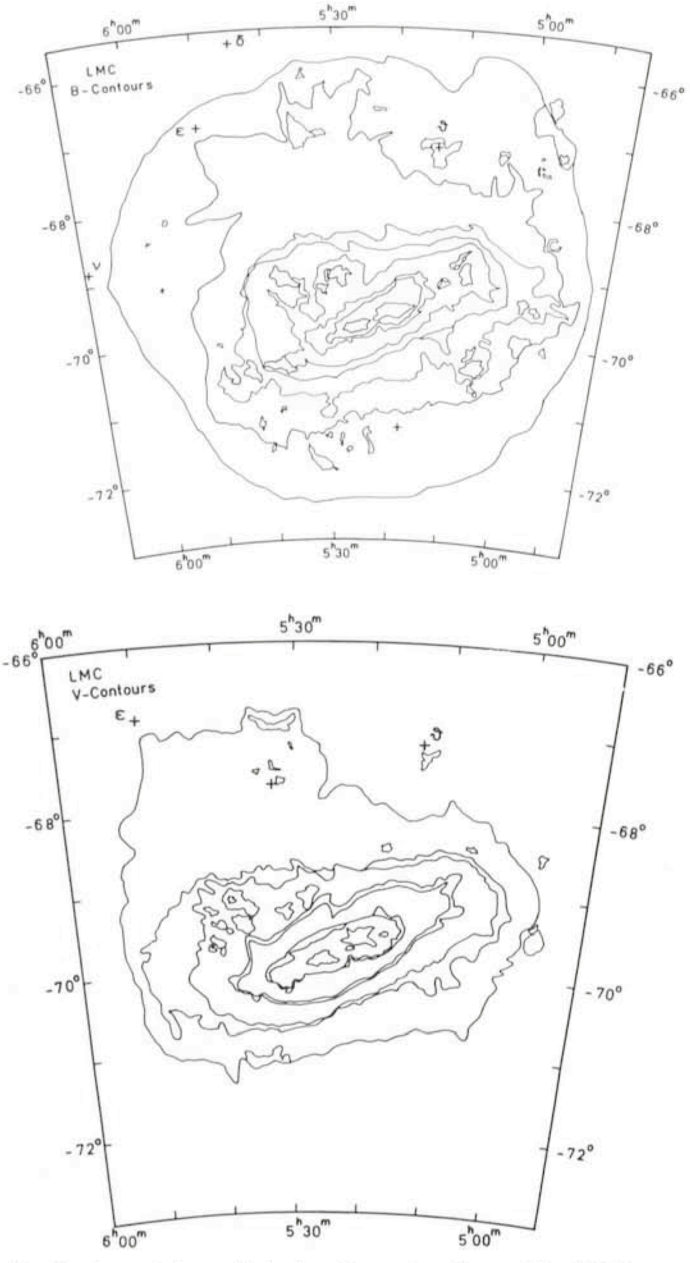


Fig. 2a+b. — *Schematic isodensity contour lines of the LMC from B- and V-Schmidt plates.*

to the brightness distribution within the LMC (and of course in all galaxies), although the faint young population I stars no longer can be distinguished from the old population II stars of the elliptical component. The ellipsoidal structure of the bar is clearly recognized from the V-contours.

The density levels of the contours were calibrated by star counts in the following way: at positions which appeared undisturbed by interstellar material, the isodensity contour is solely determined by the total number of sub-threshold stars per surface area. They contribute according to the luminosity function. At the relevant positions of the contours, star counts to the limiting magnitudes were made on the two Schmidt plates, reaching absolute magnitudes of $M_V \sim -2\overset{m}{.}5$ and $M_V \sim +2\overset{m}{.}1$, respectively. Though the luminosity function is still increasing towards stars of fainter absolute magnitude, those below $M_V \sim +6^m$ hardly contribute to the surface brightness. Therefore a correlation should be expected between the average photographic density D of the corresponding isodensity contour and the counted star number N ($m_V \sim 21^m$). This relation is shown in figure 3.

Separation of Populations I and II

As mentioned above, the very conspicuous young stellar population I stars and HII-regions, which so clearly outline the spiral features, are no longer distinguishable from the old stellar population II of the LMC below a certain absolute magnitude. How can we then separate the young stars from the old stars in such a faint amorphous substratum? An observational approach for solving this problem is to look at the distribution of those stars, which can easily be recognized, and which exhibit specific features that permit us to classify them as either old or young objects. In the case of population II these are the RR Lyrae variable stars; for population I, we have the A- and F-type Algol eclipsing binaries (mainly before mass exchange), which appear to be absent in the population II aggregates of our Galaxy.

A search for rapid variables and RR Lyrae stars in the LMC on ESO Schmidt plates is now well under way: I am blinking in a Zeiss comparator a pair of $5\overset{\circ}{.}5$ by $5\overset{\circ}{.}5$ ESO Schmidt B-plates of the LMC, separated in epoch by 1 day. Though the progress is slow because of the enormous surface density of stars, several hundreds of variables have been found on about 25 per cent of the searched plate area. Their amplitudes are between $0\overset{m}{.}3$ and 2^m and most of them are apparently fainter than $17\overset{m}{.}5$. They add to the approximately 2,500 known variables in or in the foreground of the LMC, most of which are brighter than $16\overset{m}{.}5$. Of course all types of intrinsic and geometric variables with fairly rapid variations contribute to the new sample and no type designations can be given at this moment. However it is known from the recent investigation of Dr. J. Graham that the RR Lyrae stars in the LMC have mean apparent B-magnitudes of about $19\overset{m}{.}6$. A large portion of the detected variables will therefore turn out to be RR Lyrae stars and the rest mainly eclipsing binaries.

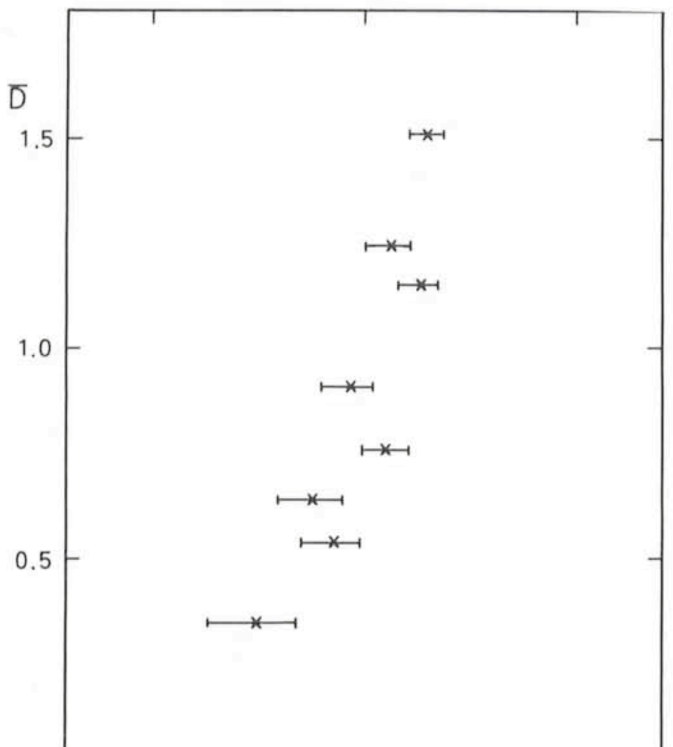


Fig. 3. — *Relation between star numbers N (m_V) and the mean density $\bar{D}$ of the contour lines of the LMC in visual light.*

Red Stars in the LMC

Another method to discriminate between the population I and II stars in the Magellanic Clouds is to search for red stars with (B-V) > $1^m.3$. Such red stars have different absolute magnitudes depending on their evolutionary status and therefore on their age. The extremely young, red stars are *supergiants* with absolute magnitudes $-6^m \leqq M_V \leqq -4^m$, or *subgiants* with $0^m < M_V < +7^m$ in the pre-main sequence evolutionary stage. In contrast, the reddest population II objects are *giants* with $M_V \sim -2^m$.

Red stars are easily found in a blink comparator by intercomparing U-plates with V-plates, which have nearly the same limiting magnitudes for A-type stars. In a first pilot survey, I blinked an ESO Schmidt U- and V-plate set along a small strip in the E-W direction, crossing the bar and the 30 Doradus complex. Hundreds of red stars were found by this method; they are especially numerous in and around the 30 Doradus nebula.

Globular Clusters

Finally, I should like to report about my study of globular clusters in the LMC. In contrast to the Galaxy where the globular clusters represent the oldest known stellar population and in which the brightest stars are red giants, very populous and young clusters have also been found in the Magellanic Clouds. Their brightest stars are blue supergiants and main-sequence objects. These enigmatic "blue" populous stellar aggregates have the same geometrical appearance as the "red" globular clusters which are quite numerous in the MC's. Obviously the formation of such rich clusters is still going on in the MC's, whereas this process died out long ago in the Milky Way and in other giant galaxies.

By studying the spatial density distribution of stars in globular clusters of very different age we may perhaps learn something about this mechanism and, above all, about their dynamical age status. The relaxation time of globular clusters is typically about $2 \cdot 10^9$ years, which is $^1/_{10}$ the age of the "red" globular clusters. These should therefore show a non-isothermal density distribution, contrary to the "blue" globular clusters, because the ages of the latter are only about $^1/_{100}$ of their relaxation time. Observationally the density distribution of spherical stellar systems can be obtained by star counts or surface photometry along parallel strips. Strip counting has now been carried out on V and B ESO Schmidt plates for two "blue" and two "red" globular clusters of the LMC. The first results indicate that differences are present in the density distribution between the two types of globular clusters.

New Publications from ESO

Most scientific papers by ESO staff astronomers and visiting scientists to the ESO Scientific Group in Geneva are now available as preprints before publication in the journals.

The "European Southern Observatory Scientific Preprints" are sent at regular intervals to all major observatories. Individual copies may be obtained by writing to:

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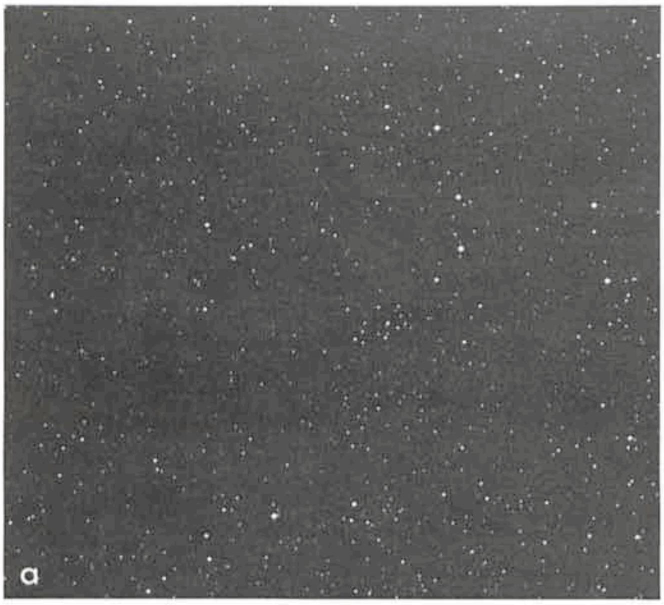
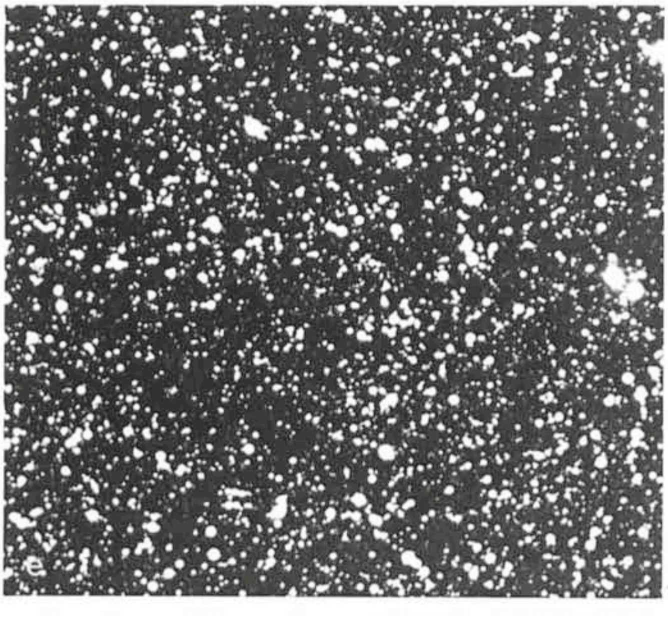
The following scientific preprints were published:

1. M.P. VERON, P. VERON: Optical Positions of Radio Sources. February 1977. Publ.: *Astronomy and Astrophysics, Suppl.* **29,** 149-159, 1977.
2. R.M. WEST, T.M. BORCHKHADZE, J. BREYSACHER, S. LAUSTSEN, H.-E. SCHUSTER: Ten New Southern Galaxies with Broad Emission Lines. February 1977. Publ.: *Astronomy and Astrophysics, Suppl.:* **31,** 55-60, 1978.
3. P. VITELLO, F. PACINI: The Evolution of Expanding Non-Thermal Sources. I + II. February 1977. I: publ. *Astrophysical Journal* **215,** 452-462, 1977. II: Submitted for publication in: *Astrophysical Journal,* March 1978.
4. G.A. TAMMANN: Statistics of Supernovae in External Galaxies. February 1977. Submitted for publ. in: 8th Texas Symp. on Relativistic Astrophysics. Annals New York Academy of Sciences.
5. M.P. VERON: Identification of Southern Radio Sources with Steep Radio Spectrum. May 1977. Publ.: *Astronomical Journal,* **82,** 937-940, 1977.
6. P. VERON: A Study of the Revised 3 C Catalogue. May 1977. Publ.: *Astronomy and Astrophysics, Suppl.* **30,** 131-144, 1977.
7. G. CONTOPOULOS, C. MERTZANDIES: Inner Lindblad Resonance in Galaxies. Non-Linear Theory. II. Bars. June 1977. Publ.: *Astronomy and Astrophysics* **61,** 477-485, 1977.
8. E.B. HOLMBERG, A. LAUBERTS. H.-E. SCHUSTER, R.M. WEST: The ESO/Uppsala Survey of the ESO (B) Atlas of the Southern Sky-V. June 1977. Publ.: *Astronomy and Astrophysics, Suppl.* **31,** 15-54, 1978.
9. W.C. SASLAW, J.A. TYSON, P. CRANE: Optical Emission in the Radio Lobes of Radiogalaxies. July 1977. Publ. Abstract: *Astron. Astrophys.* **59,** L15, 1977. Submitted for publ. in: *Astronomy and Astrophysics,* 1978.
10. A. YAHIL, G.A. TAMMANN, A. SANDAGE: The Local Group: The Solar Motion Relative to its Centroid. July 1977. Publ.: *Astrophysical Journal.* **217,** 903-915, 1977.
11. G. CONTOPOULOS: Disappearance of Integrals in Systems of more than two Degrees of Freedom. August 1977. Submitted for publ. in: *Celestial Mechanics.*
12. J. MATERNE: The Structure of Nearby Clusters of Galaxies I. October 1977. Submitted for publ. in: *Astronomy and Astrophysics,* 1978.
13. J. LUB: A Study of the Reddening and Blanketing Corrections for RR-Lyrae Stars in the Walraven VBLUW Photometric System. November 1977. Submitted for publ. in: *Astronomy and Astrophysics,* 1978.
14. G. CONTOPOULOS: Periodic Orbits near the Particle Resonance in Galaxies. November 1977. Submitted for publ. in: *Astronomy and Astrophysics,* 1978.
15. G.A. TAMMANN, R. KRAAN: The Galactic Neighbourhood. November 1977. Submitted for publ. in: *IAU Symposium* No. 79.
16. D.H. CONSTANTINESCU, L. MICHEL, L.A. RADICATI: Spontaneous Symmetry Breaking and Bifurcations from the Maclaurin and Jacobi Sequences. December 1977. Submitted for publ. in: not yet decided.
17. N.A.S. BERGVALL, T.M. BORCHKHADZE, J. BREYSACHER, A.B.G. EKMAN, A. LAUBERTS, S. LAUSTSEN, A.B. MULLER, H.-E. SCHUSTER, J. SURDEJ, R.M. WEST, B.E. WESTERLUND: Spectroscopic and Photometric Observations of Galaxies from the ESO/Uppsala List. Second Catalogue. December 1977. Submitted for publ. in: *Astronomy and Astrophysics, Suppl.,* 1978.
18. P.A. SHAVER, A.C. DANKS: Radio and Infrared Observations of the OH/H_2O Source G 12.2-0.1. December 1977. Submitted for publ. in: *Astronomy and Astrophysics,* 1978.

The "European Southern Observatory Technical Reports" are also published through the ESO Library in Geneva. This is the latest in the series:

No. 8. F. FRANZA, M. LE LUYER, R. N. WILSON: 3.6 m Telescope. The Adjustment and Test on the Sky of the Prime Focus Optics with the Gascoigne Plate Corrections. October 1977.

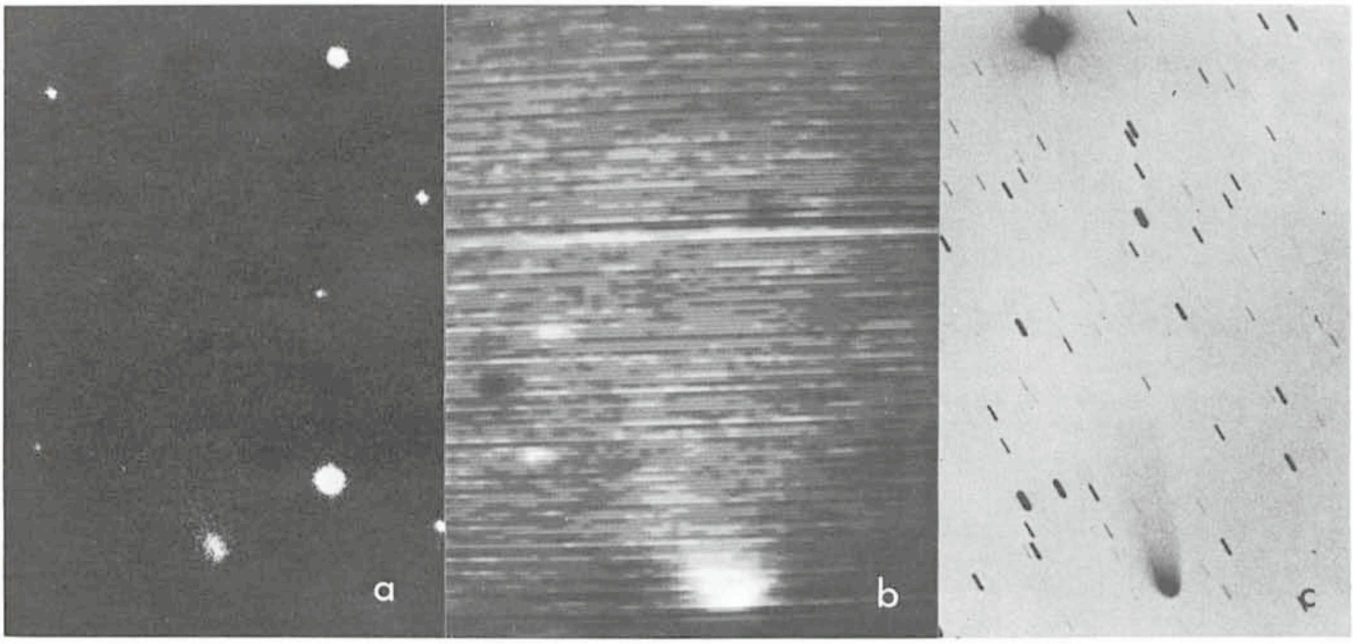




Dust in the Milky Way

Large clouds of dust shroud the light of distant stars in the plane of the Milky Way. The clouds can be perceived directly when they are very dense (cf. the Messenger *No. 10, page 5) but in most cases we only know they are there because the stars behind them are reddened. This is because they absorb much more blue than red light.*

These five photos, of the same Milky Way field in the southern constellation Centaurus, offer a convincing illustration of this reddening effect. They were all obtained with the ESO Schmidt telescope and show the stars in this direction in (a) Ultraviolet light (IIa-O + UG 1, 75 min), (b) Blue light (IIa-O + GG385, 60 min), (c) Blue + Green light (IIIa-J + GG385, 75 min), (d) Red light (098-02 + RG630, 90 min) and (e) Infrared light (IV-N + RG10, 135 min). The IIIa-J, 098-02 and IV-N plates were sensitized. The ultraviolet plate is not able to penetrate very far into space, but the infrared plate shows even very distant stars.



Three ways of seeing the new comet:
(a) the discovery image on a 20-minute ESO Schmidt plate (January 12, 1978, IIa–O + GG385);
(b) on the Quantex TV screen in the control room of the 3.6 metre telescope, on January 15, and
(c) on a 50-minute IIIa–J + GG385 plate obtained by Dr. J. Surdej in the prime focus of the 3.6 m telescope on January 20.
Photos (a) and (c) were reproduced from the original plates; (b) was photographed by Polaroid directly from the screen. On all photos, north is down and east to the right.

Another Very Distant Comet Found at ESO

1977 turned out to be a record year for comet discoveries and recoveries. Not less than 20 comets were found and most of the letters of the alphabet had to be used (the latest was Comet Lovas 1977t).

The present year also got off with a good comet start. Early in January, Dr. P. Wild discovered a 14th magnitude comet with the Schmidt telescope at Zimmerwald (Switzerland) and yet another comet was discovered at ESO, La Silla, on January 12, 1978. Since the ESO comet was reported first, it received the designation 1978a (Comet West) and the Swiss comet is now known an 1978b (periodic comet Wild 2).

1978a was found in the evening of January 12 by Dr. Richard M. West, ESO astronomer, while inspecting plates obtained with the 1 m Schmidt telescope the night before, by night assistant Guido Pizarro. The object was rather faint, magnitude 17 (see the figure) and there was some doubt about the reality. However, another plate the next morning confirmed that it was indeed a comet, slowly moving northwards. It had a rather long tail for a comet of this magnitude, almost ten arcminutes long.

Plates were obtained the following nights with the Schmidt telescope and later with the 3.6 m telescope (observers: Drs. Jean and Anna Surdej). The orbit has now been computed by Dr. Brian Marsden, who finds that 1978a is very distant; at the time of discovery, it was about 900 million kilometres from the Earth. From eight plates in January it appears that it is moving in a parabolic orbit and passed through perihelion in June 1977 at a distance of approximately 850 million kilometres from the Sun. Thus, 1978a has the third largest known perihel distance (after Comet Schuster (1975 II) and Comet van den Bergh (1974 XII)).

Two spectra were obtained with the Boller & Chivens spectrograph in the Cassegrain focus of the 3.6 m telescope. To some surprise, it appears that weak emission bands of diatomic carbon (C_2) may be present, a feature not found in distant comets. Moreover, the tail structure is indicative of the presence of a short (ion?) tail, in addition to the long dust tail. It is therefore possible that 1978a is "active", even at this large distance from the Sun.

PERSONNEL MOVEMENTS

(A) Staff

ARRIVALS

Garching

Secretariat: Sonngard DOBROFSKY (German), clerk-typist (telephone and telex operations)

TRANSFERS

Jan VAN DER VEN (Dutch), senior mechanical engineer; from Geneva to Chile, 1.1.1978

Dietmar PLATHNER (German), mechanical engineer; from Chile to Geneva, 1.2.1978

DEPARTURES

Garching

Secretariat: Lindsay HOLLOWAY (British), clerk (shorthand-typist), 31.12.1977

(B) Paid Associates – Fellows – Coopérants

ARRIVALS

Geneva

Scientific Group: Daniel KUNTH (French), Fellow, 1.2.1978

The Helium Variable HD 64740—an X-ray Binary?

K. Hunger

Professor Kurt Hunger is a frequent user of the coudé spectrograph at the 1.5 m telescope on La Silla. His work has mainly concentrated on high-dispersion spectral investigations of stars with the aim of determining their physical parameters and chemical abundances. However, as is sometimes the case in fundamental research, unexpected discoveries may result from other (unrelated) programmes. The following article is a beautiful example of such an event. Professor Hunger recently left the Technical University in Berlin to succeed Prof. A. Unsöld as director of the Kiel Institute.

In the course of the spectroscopic investigation of helium-rich stars, carried out at the Institut für Astrophysik of the Technische Universität Berlin and also at the Institut für Theoretische Physik und Sternwarte of the University of Kiel, two of the stars were found to be variable in the strength of the helium lines: σ Ori E as found by K. Hunger, and HD 37776, by S. Clas-Offick. The latter was discovered independently by P.E. Nissen of the University of Aarhus, from narrow-band photometry centered at the line He I λ 4026 Å. This powerful method was later employed by H. Pedersen and B. Thomsen, also from Aarhus, who added a number of new helium variables (cf. *Messenger* No. 11, p. 15). Among these, a total of 5 helium-rich are known at present.

Despite much effort spent to unravel the nature of the prototype of the helium variables, σ Ori E, no satisfactory solution has been found so far. Is it a spotty rotating field star (oblique rotator), or is it a close binary with an accretion disc? An argument in favour of the first hypothesis is the recent discovery of a (variable) magnetic field. The binary hypothesis, on the other hand, is made plausible by the discovery of a (variable) shell. Whatever final model will emerge, the coming and going of the helium lines must be accompanied by radial velocity shifts that amount to sizeable fractions of the observed rotational velocity, v sin = 150 km/s.

No Line Shifts

However, no shifts are readily detectable, D. Groote, Berlin, and K. Hunger, Kiel, employed a rather sophisticated method to detect radial velocity variations of amplitudes as low as 1 km/s, from 20 Å/mm spectrograms, taken at La Silla. The principle of this method is as follows: two spectrograms taken at different phases are traced on the PDS-Microdensitometer of the Institute in Kiel and the output is stored on magnetic tape. The next step is to bring the two *stellar* spectrograms to optimum coincidence by shifting in wavelength one spectrogram with respect to the other.

This is done in the computer by means of a correlation function that correlates the two spectrograms for the various shifts. The maximum of this function yields the optimum coincidence. The final step then is to find out by how much the *laboratory* lines are displaced in that given relative position. The result for σ Ori E was that no radial velocity variations with amplitudes larger than 2 km/s occur, a fact that poses a serious problem to any model.

Spectra of HD 64740

An interesting by-product of the above outlined method was obtained as follows. In order to test the accuracy, the method had to be applied to a star having no radial velocity variations, and resembling as closely as possible the spectrum of σ Ori E. These conditions are hardly met by any known stable star. Therefore, the brightest helium star that itself is a helium variable, was chosen, HD 64740, with $m_V = 4^m.6$, and several spectrograms were taken in rapid succession (exposure time ≈ 6 min) to ensure that no velocity shifts occurred between the first and the last plate. This test indeed proved the above claimed accuracy.

To make further use of these test plates, D. Groote and J.P. Kaufmann, Berlin, started a detailed spectral analysis of HD 64740, based on a computer averaged spectrum that is composed of a total of 8 spectrograms, each belonging to the phase of helium minimum, and each widened to 0.5 mm. The emulsion is Kodak IIa-O, baked in nitrogen. Figure 1 demonstrates how smooth the averaged (intensity) tracing comes out, the quality almost approaching solar standards! The observed profile of H_δ and He I 4121 is given by the full

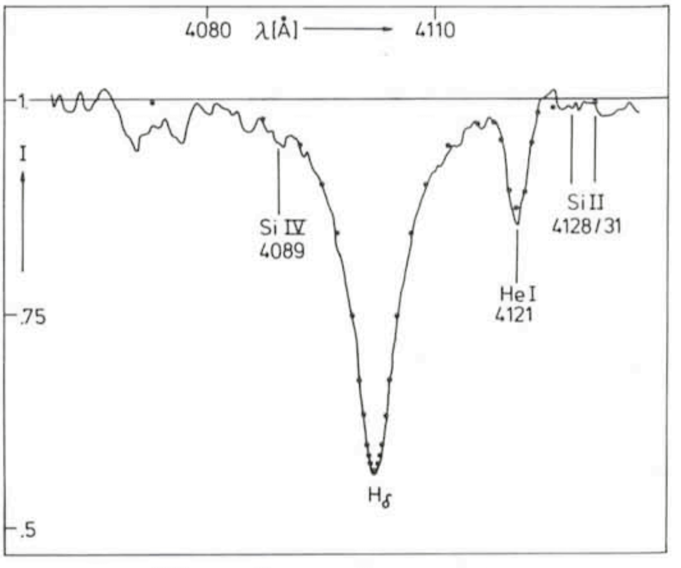


Fig. 1. — *Computer averaged spectrum of HD 64740 near 4100 Å.*

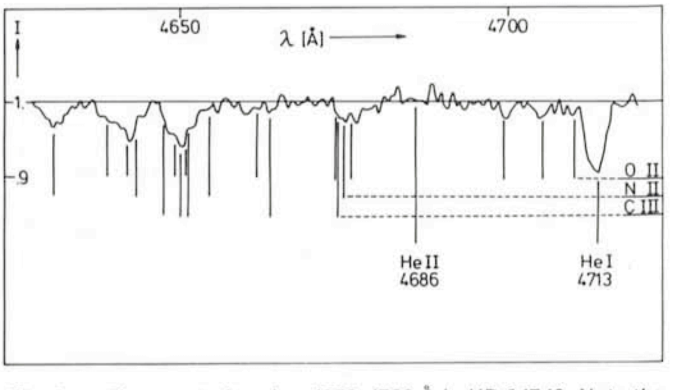


Fig. 2. — *The spectral region 4650-4700 Å in HD 64740. Note the He II 4686 emission profile with central absorption.*

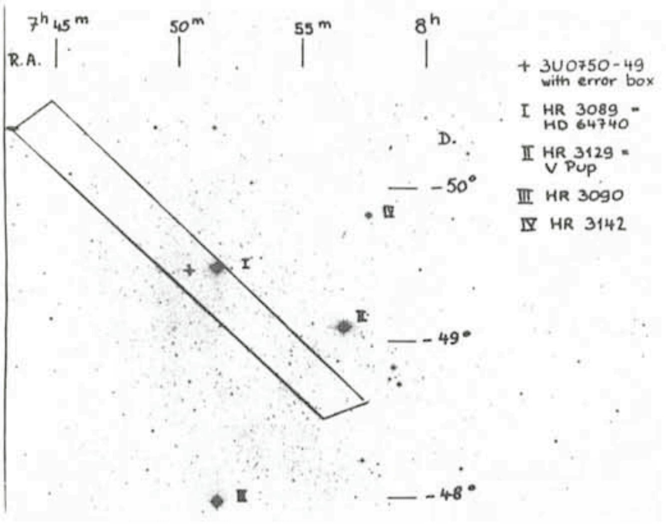


Fig. 3. — *The sky area near the X-ray source 3U 0750-49.*

line. Dots represent the theoretical profile obtained from an adapted model atmosphere. The effective temperature turns out to be exceptionally high (27,000 K), for the class of helium variables. At this temperature, the line of He II λ 4686 Å should appear in absorption with an equivalent width of 50 mÅ. Figure 2 shows a portion of the spectrum from λ 4650 to 4700 Å. No absorption line is readily detectable at λ 4686, although the weak lines of O II, N II and C III can be identified down to 20 mÅ (for identification see the right-hand scale).

Instead, a broad emission feature is indicated, with a central absorption of the anticipated strength. The emission exceeds the (well-defined) continuum by 2 per cent.

A New Class of X-ray Sources?

In X-ray binary systems, He II λ 4686 sometimes appears in emission. HD 64740 indeed is located inside the error box of the weak source 3U 0750-49 (see Fig. 3) as was noted already by Pedersen and Thomsen, whereas the contact binary V Pup, so far suspected to be the candidate, lies 3 arc min outside the error box. Better X-ray positions are needed to confirm the identification. However, if confirmed, it would mean that a new class of X-ray sources has been found. It would also solve the mystery of the helium variables, which would then be binaries containing a compact object, i.e. either white dwarf or neutron star.

The N 119 Complex in the Large Magellanic Cloud

J. Melnick

One of the most striking objects seen in blue photographs of the Large Magellanic Cloud (LMC) is a spiral-shaped H II region situated almost at the very centre of the so-called "bar" of the LMC. This H II region is generally referred to as N 119, since it is the one hundred and nineteenth entry in a catalogue of emission nebulae in the LMC prepared in 1956 by the American astronomer Karl Henize.

Figure 1 shows a negative enlargement of N 119 made from an excellent ultraviolet plate of the central region of the LMC obtained with the ESO Schmidt telescope on La Silla. On this plate, the peculiar structure of N 119 can be very clearly appreciated. It mainly consists of a bright condensation with a bright star cluster at its centre and two prominent, spiral-shaped filaments extending several arc-minutes on either side of the nuclear region. The overall diameter of the "spiral" filaments is about 8 arc-minutes or more than 100 pc, i.e. more than twenty times larger than the Orion nebula; indeed, even the central part of N 119 is already much larger than Orion!

It can also be seen in figure 1 that the area around N 119 appears to be a region of relatively recent and vigorous star formation. Several open clusters may be discerned on the photograph as well as a large number of individual stars which are significantly brighter than the field stars in the LMC bar. In addition, the whole region is covered with faint, diffuse gaseous filaments.

What is the nature of this peculiar object? Are the spiral-shaped filaments only the densest parts of a gigantic spherical shell of gas seen projected against the plane of the sky? If so, is this shell expanding? Or are the filaments really thin wisps of gas in the interstellar space? With these questions in mind, and as part of a more general programme, investigating the internal kinematics of giant emission nebulae in external galaxies, I have obtained accurate velocity profiles at the positions along the "arms" of N 119 as indicated in figure 1.

The Fabry-Pérot Spectrometer

The instrument used for this work was a photoelectric Pressure-Scanned Fabry-Pérot Spectrometer at the 1.5 m telescope of the Cerro-Tololo Interamerican Observatory. The principle of operation of the Fabry-Pérot interferometer is illustrated in figure 2.

It basically consists of two parallel, semi-transparent mirrors. Parallel light entering the cavity formed by the two mirrors undergoes multiple reflections inside the cavity, producing the interference pattern shown in figure 3. When perfectly monochromatic light is fed into the cavity, it is then concentrated by the interferometer in very narrow rings, each corresponding to the same wavelength, but to a different interference order. Assuming that the mirrors are perfectly parallel, the resolution of the interferometer is given by the width of the rings which in turn depends on the number of reflections inside the mirrors and on their separation. With the advent of low-absorption dialectric multilayer coatings, very narrow rings can be produced.

In typical astronomical use the wavelength of the line to be studied is first preselected, usually by means of interference filters. However, the observed light is still not monochromatic and the width of the rings depends also on the intrinsic width of the observed line. Since the "instrumental" width of the rings is very small, very accurate information about the shape of the observed lines can be obtained.

Typically, Fabry-Pérot interferometers are used in two modes: In the first, more classical mode, a Fabry-Pérot is placed in front of a photographic camera, for instance to

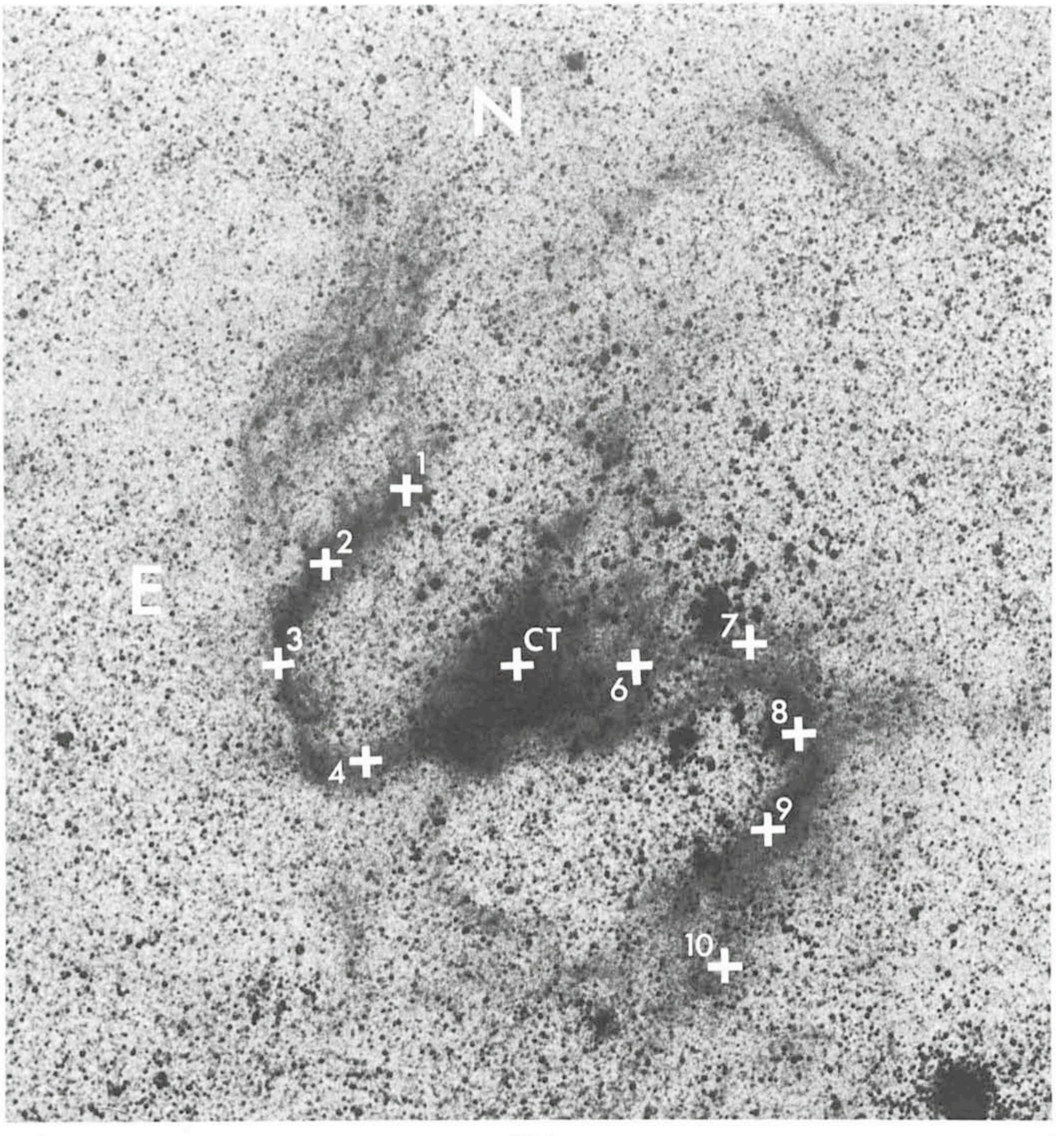


Fig. 1.

investigate the kinematics of emission nebulae (cf. the article by M.F. Duval in *Messenger* No. 8).

In the second mode, the light from the Fabry-Pérot plates is fed into a photomultiplier. The rings are then scanned by changing the length of optical path of the light inside the cavity, either by changing the separation of the plates or by changing the index of refraction of the medium inside the cavity (by increasing the amount of gas between the two mirrors).

But what is the advantage of Fabry-Pérot interferometers over conventional slit-spectrographs? Well, the resolving power of the Tololo interferometer is about 50,000. To achieve a similar resolving power using conventional coudé spectrographs, the entrance slit must be of the order of 0.1 arc-second and with typical seeing conditions of 1 arc-second, only a few per cent of the light would actually be

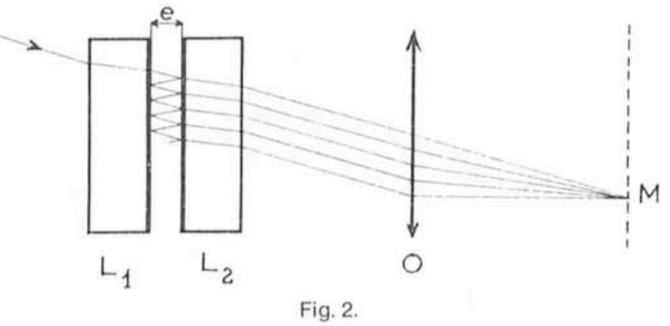


Fig. 2.

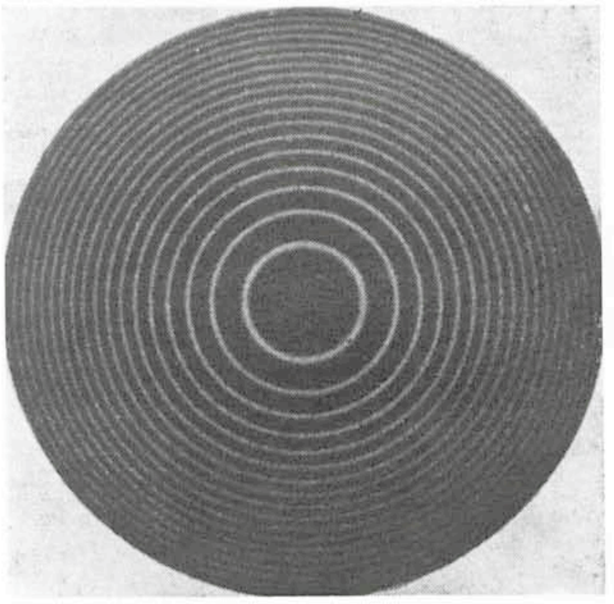


Fig. 3.

used! By contrast, F-P interferometer entrance apertures as big as several minutes of arc can be used without degrading the resolving-power. Thus, they are superior for the investigation of the kinematics of extended objects. It should not be forgotten, however, that when using F-P spectrometers only one line can be looked at at the time!

The interferometer used in the present investigation works in the pressure-mode. The amount of nitrogen gas inside the cavity is continuously increased by a computer-controlled valve while the output of the photomultiplier is read at fixed intervals.

The radial velocity of the gas is obtained to an accuracy of about 1 km/sec by comparing the measured nebular profiles with those of a standard hydrogen lamp on the instrument, by using a computer line-fitting programme.

Observations of N 119

The results for N 119 are shown in figure 4 where the difference in velocity (ΔV) between the individual positions observed and their mean value (a heliocentric velocity of 276 km/sec) has been plotted as a function of distance to the N 119 centre projected along the line joining Positions 1 and 9 in figure 1. It is seen that there is a systematic increase in velocity from the southern end of N 119 to the tip of the norther "arm".

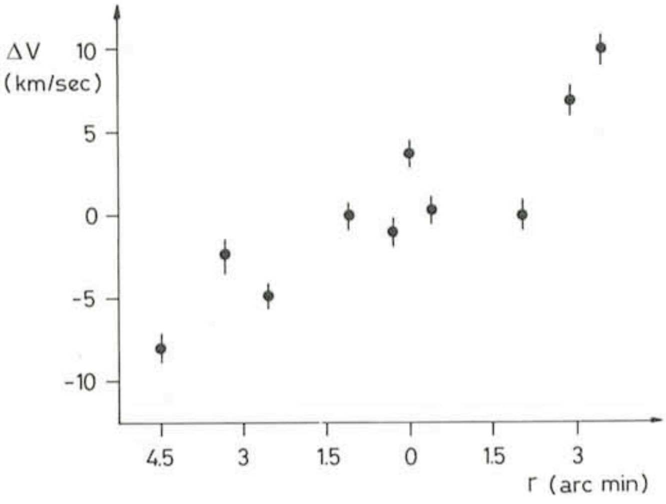


Fig. 4.

Is this the consequence of the general rotation of the LMC? The LMC, as a whole, rotates around an axis roughly perpendicular to the (1 to 9) axis of N 119. Therefore, the motions in N 119 ought to reflect those of its parent galaxy. However, in its central regions, the LMC rotates as a solid body with a velocity gradient (along an axis nearly parallel to that of N 119) of about 20 km/sec/deg. Over the observed length of N 119 (7.5 arc-minutes) one expects a velocity difference of only 3 km/sec, i.e. much less than the observed 18 km/sec! The observed velocity field must, therefore, be intrinsic to N 119.

A possible explanation for this velocity field is that the arms of N 119 are just the densest parts of an expanding shell. If this were the case, however, one would expect to see a double-peaked profile at the centre of N 119 with a separation significantly larger than 18 km/sec, when projection effects are considered. The profiles do not show such a structure, although the resolution of the interferometer is about 9 km/sec. However, the profiles do show a certain asymmetry towards lower velocities. The possibility of expansion cannot, therefore, be entirely discarded.

The Structure of N 119

We notice in figure 1, that N 119 has a structure somewhat resembling two spherical shells joined at the centre of N 119. In fact careful inspection of the photo reveals that N 119 has a "figure 8" shape.

But how was this strange structure formed? There are two plausible mechanisms. The first, and perhaps the most classical, is supernova explosions. Here, a star reaches the end of its life and explodes while ejecting large amounts of material at very high velocities. This material then sweeps out the surrounding interstellar gas and is decelerated by what could be called interstellar "friction", forming gigantic loops. An alternative and very attractive mechanism has often been invoked in recent years. Bright supergiant stars (such as Wolf-Rayet stars) are known to loose large amounts of mass from their atmospheres at velocities reaching thousands of kilometres per second. These so-called "stellar winds" act upon the interstellar medium more or less like a supernova blast, producing what has been called "an interstellar bubble".

Since a stellar wind continuously drives the bubble outwards, while a supernova blast gives it only one huge energetic push, there are certain physical differences between the two mechanisms which in principle might allow us to distinguish between the two possible origins for the observed bubbles. This, however, is not a simple problem and it has been the subject of much research during the past few years, especially in connection with the LMC.

In the case of N 119 it is known that it contains at least one very bright supergiant star, located right at its centre. This star, called S Doradus, has been intensively studied by Bernhard Wolf. S Doradus could be driving a massive wind, but it is not easy to explain how it could produce a structure like that of N 119. On the other hand, radio observations of N 119 do not show that a supernova explosion has recently taken place near the nebula.

Clearly, a detailed study of the velocity field of N 119 would be of much help to understand the nature of this interesting nebula. The photographic Fabry-Pérot interferometer used at La Silla by the French group would be an ideal instrument for this investigation. Together with accurate radial velocity information, this instrument provides the necessary spatial resolution required to properly map the velocity field around N 119.

Visiting Astronomers

April 1—October 1, 1978

Observing time has now been allocated for period 21 (April 1 to October 1, 1978). As usual, the demand for telescope time was much greater than the time actually available.

The following list gives the names of the visiting astronomers, by telescope and in chronological order. The complete list, with dates, equipment and programme titles, is available from ESO/Munich.

3.6 m Telescope

April: Kohoutek, Courtès/Boulesteix, Kunth/Sargent, Lub/van Albada, Feitzinger/Kühn/Reinhardt/Schmidt-Kaler.

May: van den Heuvel/van Paradijs/Henrichs/Zuiderwijk, Chevalier/Ilovaisky, King, J.&A. Surdej/Swings, Geyer/Schuster.

June: Bergvall/Ekman/Lauberts/Westerlund, Ilovaisky, Westerlund, Pettersson.

July: Knoechel, Labeyrie, Swings, de Graauw/Fitton/Beckman/Nieuwenhuyzen/Vermue.

August: Laustsen/Tammann, Schnur/Sherwood, Vogt, Schultz/Kreysa.

Sept.: Boksenberg/Goss/Danziger/Fosbury/Ulrich/Schnur, Bergeron/Dennefeld/Boksenberg, Dennefeld/Materne, Turon/Epchtein, Wamsteker, Muller/Schuster/West.

1.52 m Spectrographic Telescope

April: Kunth/Sargent, Feitzinger/Kühn/Reinhardt/Schmidt-Kaler, Schmidt-Kaler/Maitzen, Rahe, Bertout/Wolf, de Loore.

May: de Loore, Ahlin, Breysacher/Muller/Schuster/West, Schnur/Danks, Ilovaisky/Chevalier, King, Briot/Divan/Zorec, van den Heuvel/Henrichs/Zuiderwijk, Thé.

June: van den Heuvel/Henrichs/Zuiderwijk, Thé, Ahlin, Pakull, Houziaux, Ilovaisky/Chevalier, Ardeberg/Maurice, Lindblad/Lodén, Hultqvist, Houziaux/Danks, Ahlin.

July: Schnur/Danks, de Loore, Swings/Surdej, Tscharnuter/Weiss, M. Jaschek, Ahlin.

August: Spite, Schnur/Mattila, C. Jaschek, Andriesse, Bergvall/Ekman/Lauberts/Westerlund, Breysacher/Muller/Schuster/West.

Sept.: Breysacher/Muller/Schuster/West, Breysacher, Querci, Bouchet, Ahlin, Wamsteker, Breysacher/Azzopardi.

1 m Photometric Telescope

April: Adam, Kohoutek, Shaver/Danks, Bensammar, Wamsteker, de Loore.

May: Chevalier, van den Heuvel/Henrichs/Zuiderwijk, Thé/Wamsteker, Zeuge, Ardeberg/Maurice, Crane.

June: Crane, Westerlund, Pakull, Gahm, Smith, Bernard.

July: Bernard, Knoechel, de Loore, Salinari/Tarenghi, Sherwood/Arnold, Wamsteker, Wamsteker/Schober, Vogt.

August: Vogt, Bruch, Alcaíno, Bouchet, Querci, Vogt, Schnur/Mattila.

Sept.: Schnur/Mattila, Fosbury, Bergvall/Ekman/Lauberts/Westerlund, Blair, Turon/Epchtein, Wamsteker, Wamsteker/Schober, Crane/Materne, van Woerden/Danks.

50 cm Photometric Telescope

April: Rahe, Kohoutek, Lodén.

May: Lodén, Debehogne, Briot/Divan/Zorec.

June: Heck, Pakull.

July: Pakull, Haefner, Swings/Surdej, Bouchet.

August: Bouchet, Schober/Surdej, Schnur/Mattila.

Sept.: Schober/Surdej.

40 cm GPO Astrograph

April: Debehogne, Vogt

May: Gieseking.

June: Ardeberg/Maurice, Gieseking.

July: Gieseking.

August: Gieseking, Vogt.

Sept.: Vogt.

50 cm Danish Telescope

May: Lindblad/Lodén, Thé/Bakker.

June: Lindblad/Lodén.

61 cm Bochum Telescope

April: Semeniuk.

May: Semeniuk, Zeuge.

June: J.&A. Surdej, Terzan.

July: Terzan, Wamsteker/Schober.

August: Walter, Walter/Duerbeck.

Sept.: Walter, Walter/Duerbeck, Wamsteker/Schober.

Comet Bradfield (1978c)

A new, bright southern comet was discovered by the Australian amateur astronomer William A. Bradfield on February 4, 1978. A preliminary orbital calculation shows that it may reach 4th magnitude during March, very low in the eastern sky, just before dawn. It was photographed with the ESO Schmidt telescope (observers: H.-E. Schuster and Oscar Pizarro) on February 8, only 25° above the horizon. The magnitude was about 8. The image of the head of the comet was somewhat trailed during the 20 min exposure, since the exact rate of motion was not yet known at that date. A short, fan-shaped tail is visible to the lower right (southwest). 20 min, 098–04 + RG 630 (red).

How Stars are Born

A.C. Danks and P.A. Shaver

There is a vivid interest among astronomers in the early phases of star formation. In the last issue of the Messenger *(No. 11, p. 14) a catalogue of stellar birth places was introduced. The present article discusses radio, infrared and optical observations of a particularly interesting object. The authors are Drs. Anthony C. Danks (ESO-Chile) and Peter A. Shaver (Kapteyn Astronomical Institute, University of Groningen, the Netherlands).*

In recent years both radio and infrared astronomy have revealed details of the dusty environment of star formation. These regions are characterized by the presence of "Compact H II regions" (compact, bright radio continuum sources — Mezger *et al.*, 1967), which are often associated with H_2O and type I OH masers (showing 1665 and 1667 MHz emission — Habing *et al.*, 1972). Infrared sources (1 to 30 μm) are often seen in or nearby the compact H II regions and sometimes combinations of these sources can be found close to visible H II regions.

The "Cocoon" Model

These regions can best be explained quantitatively by the recent models of Kahn (1974) and Cochran and Ostriker (1977), who propose the following scenario: A protostar ($M \approx 40\ M_\odot$) forms by accretion in a dusty interstellar cloud. As the star's luminosity increases with time, the accretion is halted by radiation pressure. A dusty "cocoon" remains, within which is a smaller ionized zone surrounding the star. In this phase the dust and gas are competing for stellar photons and a situation can arise where the dust is heated to a higher temperature than the surrounding gas and can give rise to the necessary infrared radiation capable of pumping the H_2O and OH masers. As the star evolves the cocoon fragments and the compact H II region become visible. At a later stage, as the star settles into the Main Sequence and the dust shell dissipates further, a conventional Strömgren sphere (H II region) may become visible. This later stage may be exemplified by regions such as S88B (Pipher *et al.*, 1977) or Sharpless 2–106 (Sibille *et al.*, 1975) where visible Hα emission is seen. Here the infrared source may be interpreted as an O star with high visual extinction due to dust.

Observations at Westerbork and La Silla

To investigate the various phases and accompanying physics of these regions, the authors have instigated a programme to study regions of star formation using the ESO infrared equipment at the 1 m ESO telescope at La Silla.

First results of this programme are shown in Figures 1 and 2. In Figure 1 the radio brightness contours are shown for the source G12.2–0.1. These observations were made with the Westerbork Synthesis Radio Telescope at a wavelength of 6 cm; the beam size was 6x31 arcseconds. The compact H II region is indicated by A and two other radio bright regions are indicated by B and C. Although the Westerbork beam is elongated at this low declination, the radio contours can still be seen to trace out a shell-like structure. We have marked also the positions of the OH source (Evans, private communication) and H_2O sources (Genzel and Downes, 1978).

Subsequent mapping of the region at 2.2 μ at La Silla using a 10 arcsec diaphragm and 37 arcsec chop on the sky revealed 3 infrared sources. Two are shown in Figure 1, indicated as IRS 1 and 2; the third was detected in the reference beam and is just outside Figure 1. Of these sources, IRS 1 is the most interesting, coinciding with the compact H II region. Recent position measurements of the H_2O source by Jack Welch and Mel Wright using the Hat Creek Interferometer put component A, IRS 1, and the H_2O source within 2 arcsec or 0.03 pc — an unusually close association (the source distance of 3.7 kpc was estimated from the H110α, H_2CO, OH, and H_2O radial velocities).

We have measured the spectrum of IRS 1 from 1 to 5μ and this is shown in Figure 2. The upper line in Figure 2 repre-

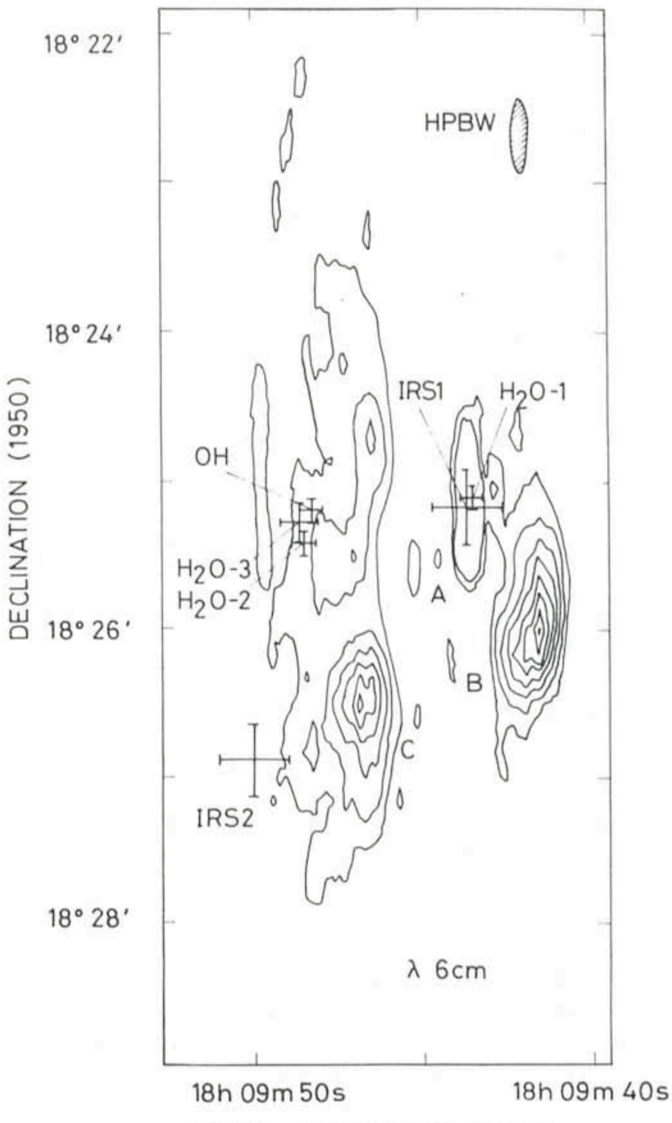


Fig. 1. — *6 cm map of G12.2–0.1. The hatched ellipse shows the half-power beamwidth. Three continuum sources are indicated as A, B and C. The positions of the OH, H_2O and infrared sources are shown as crosses.*

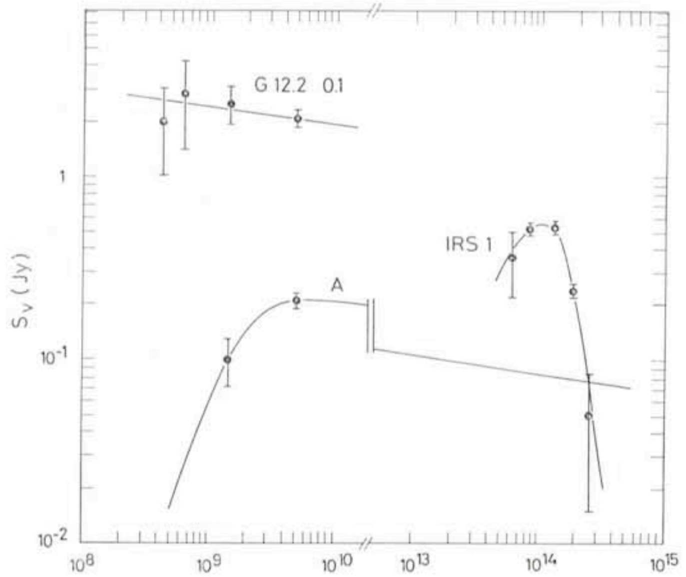


Fig. 2. — *Continuum spectrum of the entire G12.2–0.1 complex (top) and for component A and IRS 1 (bottom).*

sents the total integrated radio flux densities for the entire region. The infrared spectrum of IRS 1 appears to be stellar, an O3–O5 type star with $A_V \approx 23$ mag. However such an early O star would be capable of ionizing an H II region with 100 times the flux of the observed radio source G12.2–0.1. If the star were of spectral type O5 or later then most of the near-infrared emission could arise from a hot circumstellar cocoon (> 1000 K), and even an O7 star would still be capable of powering the radio source. The close H_2O maser association further strengthens our belief that IRS 1 is a cocoon star. Further, longer wavelength infrared observations are planned in the coming season in order to determine the spectral type of IRS 1.

Sources of this nature are often associated with large molecular complexes, and ^{13}CO observations have recently been carried out by Michael Scholtes at McDonald. ^{13}CO emission has been detected, and ^{12}CO observations will be made in the near future.

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A Magic Eye for Astronomical Spectrophotometry

The ability of a telescope to detect faint celestial objects not only depends on the linear size of the telescope, but also upon the efficiency of the light detectors that are used to register the light. For many years, most astronomical spectra were obtained on photographic plates. However, even the best of these rarely achieve detective quantum efficiencies above a few per cent, i. e. they only "catch" two or three out of every one hundred photons hitting the emulsion. During the past decade much effort has therefore been concentrated in astronomy on how to improve the detector efficiency in order to make small telescopes "larger" and large telescopes "very large". For instance, a telescope with a mirror diameter of one metre and a detector efficiency of 50 per cent is (for many astronomical applications) equivalent to a 5 metre telescope with a 2 per cent detector.

In this article, ESO engineer Rudi Zurbuchen from the Geneva group discusses one of the new detectors, the RETICON array.

New Detectors in Astronomy

Times when astronomers forgot their numb fingers, whilst gazing through the eyepiece of a telescope and admiring celestial objects are definitely over. Today's astronomy and the use of its large optical telescopes require less subjective and much more powerful eyes. In many astronomical applications electronic detectors are more and more taking over from the photographic plate. One of them, planned to be used with the instruments of the ESO 3.6 metre telescope, is described here. The actual hardware and software system is presently being developed by a team of ESO's Instrument Development Group and will be the subject of a subsequent article.

A large amount of significant astronomical information such as physical state, material composition and radial velocity of a stellar object is retrieved from the precise measurement of the object's spectrum. The light levels associated with spectrophotometric measurements on a good observing site can be very low and the requirements imposed upon efficient light detectors used in this field are accordingly high.

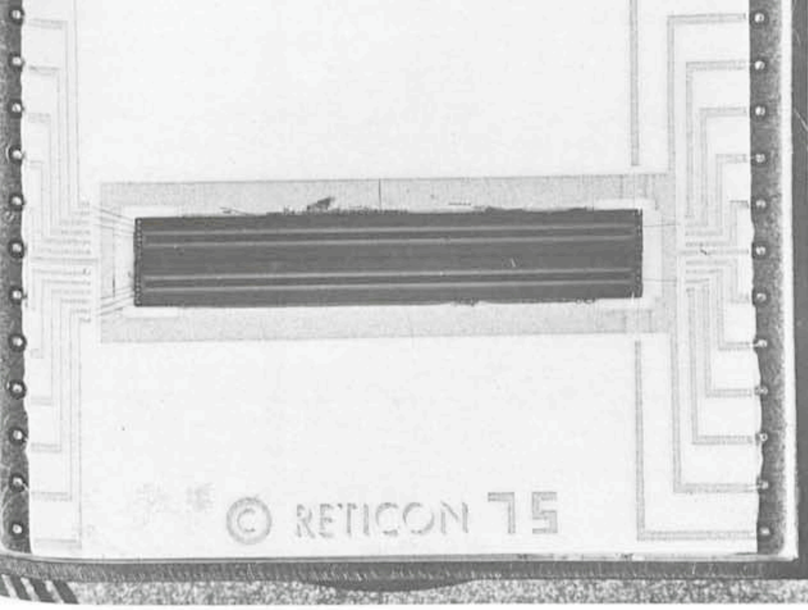
The widely-used singel-channel scanning mode of conventional spectrometers suffers badly from a poor detection efficiency which is partly due to the high light loss inherent to the sampling principle but also to the modest quantum efficiency of even modern photon multiplier tubes. An additional disadvantage of the single-channel scanner is its sensitivity to atmospheric variations.

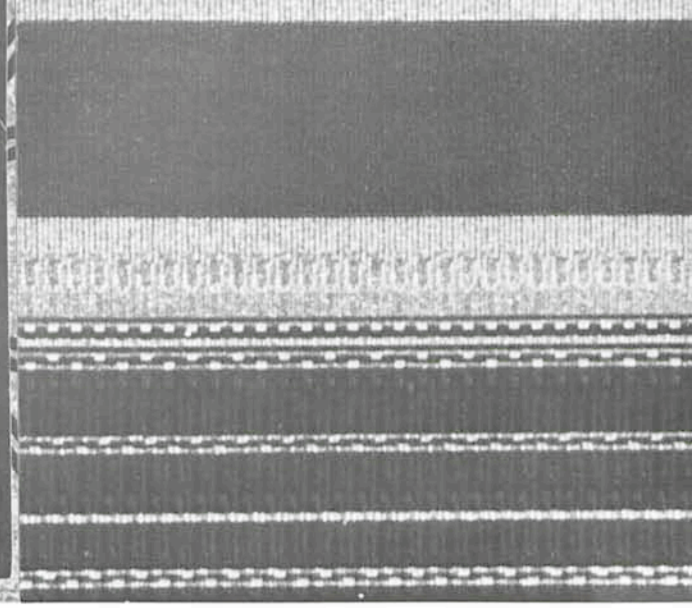
The RETICON Diode Array

Among the flood of newly-developed electronic photodetectors there is one which is particularly attractive for spectrophotometric applications. It is a self-scanned linear photodiode array manufactured by the RETICON Corporation, Sunnyvale, California. Several other array devices are potentially good competitors but the RETICON seems, at least for the time being, to be the only one which provides as well a diode sufficiently large to cover a typical astronomical spectrum image over its total height, as an adequate linear field and thereby spectral range.

Reticon linear arrays are available with up to 1872 individual photodiodes with centre-to-centre spacings as small as 15 μm. The first RETICON which will be used for the 3.6 m telescope instrumentation programme is a dual 1024-element array with a 25 μm centre-to-centre spacing and an active aperture width of 430 μm. The dual configuration allows simultaneous integration of object and background signals and will be used as a near infrared detector for the low-dispersion spectrograph of the 3.6 m telescope Cassegrain focus. Another similar array is planned to be operated on the coudé échelle high-dispersion spectrometer (see article by D. Enard in *Messenger* No. 11, December 1977).

The RETICON is a monolithic integrated circuit and as such exhibits excellent geometric accuracy and stability. Besides the photodiodes, the circuit has integrated into the same silicon chip the analog switching circuitry needed for reading out the diode





The left photograph shows a dual 1024 photodiode (RETICON) array. The two array chips, each with an active area 25 mm long and 0.43 mm high are the dark, rectangular elements mounted in the centre of their common ceramic substrate. The right picture shows an enlargement of part of an array on which the individual photodiodes (each 0.025 mm wide) may be discerned together with part of the read-out electronics on the chip.

signals sequentially by commutating one after the other to a common video line. The dual array package is shown in the figure.

Associated with each photodiode is a small capacitance upon which an electric charge can be stored by reverse biasing the diode and then allowing it to float. Electronhole (e–h) pairs generated in the diodes due to incident photons (the signal) and to thermal effects (dark current) will slowly discharge the diode capacitance until some specified integration time has elapsed, at which point each diode in its turn is again reverse biased. The amount of charge required to re-bias each individual diode is then a measure of signal plus dark current.

In contrast to the scanner principle, where the signal of only one single spectral element is integrated over a given sampling time, the entire spectrum is projected onto the RETICON surface and the total photon flux is simultaneously detected and integrated as charge, in the case of the diode array. This results in a tremendous increase in efficiency and elimination of atmospheric noise.

The useful response of silicon photodiodes ranges from 0.3 μm to 1.1 μm and within the 4000 Å to 10000 Å region it surpasses the performance of any conventional photocathode. A maximum responsive quantum efficiency (RQE) of 80 per cent is reached (!) in the 7000 Å to 9000 Å region and contributes to the overall performance of the detector.

The Noise

Several sources of noise must be considered. Various noise components associated with reading and processing the charge signals imply that extreme care must be given to the design of the analog electronic circuitry. The total readout noise of a single readout can be minimized to a noise equivalent charge (NEC) of about 800 e–h pairs and sets the absolute low limit of the dynamic signal range. The high limit is determined by the saturation charge of the diode or any other saturation effect in the signal processing. A typical dynamic range of four decades (10,000) can be reached, within which the detector can be considered as linear.

In principle a single measurement may consist of one long exposure or of a series of short coadded ones. But since the noise per readout is constant, it can readily be seen that the detective quantum efficiency (DQE) for low light levels is increasing with exposure time and therefore a single integration and reading gives by far the best result.

As already mentioned, diode capacitance discharge is not only resulting from the incident photons, but also from thermal e–h pair recombination. As a result the RETICON has to be cooled to a temperature as low as –150° C in order to make the dark noise nearly negligible. Unfortunately cooling results in a rapid drop of the RQE at the IR end of the spectral range. Consequently, higher sensitivity at higher temperatures has to be paid for with increased dark noise in this particularly interesting spectral region. Or, in other words, above 8000 Å the limiting magnitude of the RETICON decreases markedly. Incidentally, another limiting factor at the IR end is an increase in crosstalk between adjacent diodes and loss in effective spectral resolution. This effect is attributed to the increasing transparency of silicon at longer wavelengths, which in turn leads to a deeper penetration of red photons and a bigger lateral charge diffusion covering more than one diode width.

Summing up, the RETICON self-scanned linear photodiode array has, by virtue of its high sensitivity over a wide range of wavelengths, its high dynamic and linear signal range and its relative operational simplicity, an excellent application in astronomical spectrophotometry.

Garden Party at ESO Guesthouse

The Director-General invited the participants of the IAU meeting, held in Santiago from January 16 to 19, to a garden party in the ESO Guesthouse.

About 120 guests came: Chileans and people from other Latin American countries, USA and Europe, partly with wives and children.

Apart from a lovely garden in full bloom, ESO was able to offer a candle-lighted summer night, a full moon in the sky, folkloristic dancing and music, and last but not least, nice cool drinks and an appetizing cold buffet.

The guests seemed pleased and so were the hosts: Prof. Woltjer, ESO astronomers and the ESO/Chile administration.

NEWS and NOTES

Move to Munich Delayed

The Max Planck Society has informed ESO that there will be some delay in the construction of the ESO Headquarters Building in Garching. This is mainly due to new legal provisions in Germany imposing stricter regulations on the thermal insulation of buildings. As a consequence, it has been necessary to review the technical specifications of the ESO building.

It is now estimated that the construction will be terminated in the early summer of 1980 and that the move into the new Headquarters may take place soon after.

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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ALGUNOS RESUMENES

Otro cometa muy distante fue descubierto en ESO

1977 resultó ser un año récord para los descubrimientos y redescubrimientos de cometas. Fueron encontrados no menos de 20 cometas y se tuvieron que usar la mayor parte de las letras del alfabeto (el último fue el cometa Lovas 1977t).

También el presente año ha partido con un buen comienzo para los cometas. En los primeros días de enero el Dr. P. Wild descubrió un cometa de magnitud 14 con el telescopio Schmidt en Zimmerwald (Suiza) y otro cometa fue descubierto en ESO, La Silla, el día 12 de enero de 1978. Ya que el cometa de ESO fue anunciado primero, fue llamado 1978a (Cometa West) y el cometa suizo es conocido como 1978b (cometa periódico Wild 2).

1978a fue descubierto en la noche del día 12 de enero por el Dr. Richard M. West, astrónomo de ESO, mientras inspeccionaba las placas que había obtenido el asistente nocturno Guido Pizarro con el telescopio Schmidt la noche anterior. El objeto era bastante pálido (magnitud 17) y hubo alguna duda sobre su realidad. Sin embargo, otra placa en la mañana siguiente confirmó que realmente era un cometa que se movía lentamente hacia el norte. Para un cometa de esta magnitud tenía una cola bastante larga, de casi 10 minutos de arco.

La órbita ha sido computada por el Dr. Brian Marsden, quien ha verificado que 1978a se encuentra muy distante; cuando fue descubierto se encontraba a alrededor de 900 millones de kilómetros de la tierra. De ocho placas tomadas en enero se puede notar que se mueve en una órbita parabólica y que ha pasado por el perihelio en junio de 1977 a una distancia de aproximadamente 850 millones de kilómetros del sol.

CHIRON: Un nuevo planeta en el sistema solar

En octubre último, Charles T. Kowal de los Hale Observatories en Pasadena, California, ha descubierto un nuevo planeta en el sistema solar. Una primera estimación puso a 1977 UB (como fue llamado) a la distancia de aproximadamente Urano, a casi 3000 millones de kilómetros.

Se mueve en una órbita bastante elíptica (e=0.38) con un perihelio justamente dentro de la órbita de Saturno y un afelio cerca de la de Urano. El período orbital es algo superior a 50 años.

Por la magnitud puede estimarse que 1977 UB tiene un diámetro de algunos cientos de kilómetros. Seguramente es uno de los primeros miembros conocidos de una nueva clase de asteroides fuera de la órbita de Júpiter, y Kowal ha propuesto el nombre CHIRON (un centauro en la mitología griega). Sin embargo, aun existe la posibilidad que sea un cometa; a distancias muy lejanas puede ser muy difícil de notar la diferencia cuando no se muestra cola, y la «cabeza» es perfectamente semejante a un astro.

En página 6 de esta publicación mostramos dos fotografías de 1977 UB, tomadas con el telescopio Schmidt de ESO en los días 9 y 10 de enero de 1978, que muestran el movimiento del objeto. Al medir las distancias hacia las estrellas que lo rodean, el lector atento notará que 1977 UB ha cambiado ligeramente su posición en la segunda fotografía.

Recepción en los jardines de la Casa de Huéspedes de ESO

Los participantes en la reunión de la Unión Astronómica Internacional (UAI) celebrada en Santiago entre los días 16 y 19 de enero, fueron invitados a una recepción en los jardines de la Casa de Huéspedes por el Director General.

Vinieron aproximadamente 120 huéspedes: chilenos y personas de otros países latino americanos, Estados Unidos y Europa, algunos con sus esposas e hijos.

Aparte de un precioso jardín en plena flor, ESO pudo ofrecer una noche de verano a luz de velas, luna llena en el cielo, danzas y música folklórica, y además, exquisitos tragos frescos y un apetitoso buffet frío.

Los huéspedes parecían satisfechos, y así se mostraron los dueños de casa: el Profesor Woltjer, los astrónomos de ESO y la Administración de ESO en Chile.

LATEST NEWS

1978 CA

A new minor planet of Apollo type was found by H.-E. Schuster on February 8, 1978. Observations continued through the full-moon period and it is now (24.2) known that it will pass within 18 million kilometres from the Earth in the early morning of March 8. The orbit is slightly larger than that of the Earth and the orbital period is 436 days. The discovery of an Apollo planet *before* the closest encounter is a rare event.

(28.2) Another Apollo-type planet, 1978 DA, was discovered within a week of 1978 CA, also by Dr. Schuster. More details will follow in the next issue of the *Messenger*.