THE MESSENGER

EL MENSAJERO

No. 10—September 1977

3.6 m Telescope Receives First Visiting Astronomers

The 3.6 m telescope is now ready to receive the first visiting astronomers. For most astronomers in Europe, this will be the first time they have access to a large telescope and it is therefore of some interest to learn how European astronomers expect to make use of their new instrument.

Preliminary information is available from the programme proposals that were received by the Observing Programmes Committee by April 15, 1977, soliciting observing time during period 20, from October 1, 1977 to April 1, 1978.

A total of 49 applicants submitted 54 programmes, of which 26 could be accepted within the time available (see p. 9). These programmes can be divided as follows (number of accepted programmes in parentheses):

1 (1) Solar system
16 (7) Milky Way (among these 9 for stars, 4 for star clusters, 2 for interstellar matter, 1 for galactic structure)
11.5 (3) Magellanic Clouds
1 (1) Sculptor dwarf galaxy
21 (12) Other galaxies
3.5 (2) Quasars.

The lack of large telescopes in Europe has traditionally restricted European investigations of distant objects like quasars and galaxies, but these figures clearly show that the interest in doing extragalactic research with the 3.6 m telescope is strong among European astronomers. The quantitative balance between galactic and extragalactic proposals is worth noticing as well as the continuation of research in the Magellanic Clouds, since long underway with the ESO 1 m, 1.52 m and Schmidt telescopes.

The accepted programmes span a wide range of subjects, from "The Iapetus eclipse on January 8, 1978" (Dr. A. Brahic, Paris) to "Spectroscopy of variable quasars" (Dr. J. P. Swings, Liège). In addition to the standard ESO equipment for photometry and spectroscopy, special equipment will be used by Drs. Y. Georgelin and G. Comte (Marseille) for "H II regions and kinematics of southern galaxies" and Drs. G. Schultz and E. Kreysa (Bonn) for "Submillimetre and IR investigations of radio sources".

ESO's Fifteenth Anniversary (1962–1977)

On October 5, 1977, ESO celebrates its fifteenth anniversary. As the first international organization for astronomy in Europe, ESO was born in October 1962 when representatives of five of the present six member states signed the ESO Convention in Paris. Ratification followed a year later and the La Silla site was chosen in 1964 where astronomical observations started in 1968 with the 1 m photometric telescope. Eight other telescopes have been added since.

The creation of ESO has had a large impact on European astronomy and the influence of the organization is increasingly being felt—also beyond the boundaries of the member states.

PROFILE OF A VISITOR'S PROGRAMME:

The Bright Cloud B in Sagittarius

A detailed study of stars in the direction of the centre of the Milky Way is underway at the Observatoire de Lyon in France by Dr. A. Terzan and his collaborators. Important material has been obtained with the ESO telescopes during the past years. Dr. Terzan outlines his programme:

A photometric study in R ($\lambda_{eff} \sim 6400$ Å) and IR ($\lambda_{eff} \sim 8100$ Å) of certain regions in the bright stellar cloud B in Sagittarius has been undertaken by the Lyon Observatory since

1959. Photographic observations at Observatoire de Haute-Provence (OHP) with the 80 cm (f/6, Newton focus) and 193 cm (f/5, Newton focus) telescopes have enabled us to discover 11 stellar clusters of which 8 are globular as well as a very large number of variable stars for which a photometric study is now being carried out.

A long series of B and R observations of the same fields were obtained in 1968 by means of the 48-inch Schmidt telescope on Mount Palomar. Many of these photographic plates have not yet been studied, because until recently the Lyon Observatory did not have a blink comparator that could accommodate plates larger than 25 x 25 cm. However, a new blink comparator has now been built which permits measurements on plates up to 30 x 30 cm and detection of magnitude variations of less than $0^m.2$. The (X, Y) position of a star is measured in an orthogonal system with arbitrary origo (X_0, Y_0).

In 1972 we started another series of photographic observations with an image-tube camera (ITT 4708, S20 extended red photocathode) at the f/15 Cassegrain focus of the ESO 1.52 m telescope. The aim was to find and to study the RR Lyr-type variables in a number of globular clusters which had already been observed at OHP.

Now, with the improved blink comparator and a fully digitized Iris photometer (Askania, automatic iris) available, a group of astronomers consisting of scientists from the Institut d'Astrophysique in Paris and the Lyon Observatory is proposing to perform a detailed photometric study of the bright cloud B in Sagittarius, within the area:

$$17^h \leqq \text{R.A.} \leqq 18^h \text{ and } -24^\circ \geqq \text{Decl.} \geqq -33^\circ,$$

centred approximately on the star 45 Oph (R.A. = $17^h 26^m$; Decl. = $-29^\circ 59'$). The principal aims are:

(1) the study of known variables in that region,

(2) the detection of new variable stars by
- the new blink comparator and
- photoelectric photometry, in particular to find the δ Scuti variables,

(3) the measurement of particularly red stars, either intrinsically red or reddened by interstellar absorption,

(4) the estimate of the interstellar absorption in the direction of the galactic centre,

(5) the search for a possible correlation between the type and the spectral distribution of the identified variable stars,

(6) the determination of the distances to the numerous globular clusters which are either situated or projected into this direction.

The photographic observations commenced in June 1976 with the ESO Schmidt telescope. H.-E. Schuster and his collaborators have already obtained 21 plates in B and R of excellent photometric quality, mostly under good seeing conditions. They cover a field of about 10° square, centred on 45 Oph. Each field has been photographed at least twice with the following exposures: B (IIa-O + GG 385) 20 and 40 minutes; R (103a-E + RG 630) 30 and 60 minutes.

A preliminary study of some of these plates was carried out in January 1977 with the blink comparator at the Sky Atlas Laboratory in Geneva and some variable stars were found around the globular cluster Terzan 2. We are now continuing the measurements of the entire set of plates and of the 1968 Palomar plates. The results will be included in a forthcoming publication.

In parallel to this work we expect to:
- complement the photographic plates with exposures in U and V, in collaboration with H.-E. Schuster, and
- establish photometric sequences in UBVRI with stars in the sky area under study. These sequences should cover a magnitude interval from V = 8.0 to V = 17.0 or, if possible, preferably fainter. We expect to use the ESO 50 cm, 1 m and 3.6 m telescopes for this purpose.

Although a large number of observational data have been gathered during the past 18 years at OHP and ESO (a total of more than 2,000 plates), they only cover relatively small fields (60 x 60 arcminutes at OHP and 3 arcminutes circular at ESO). It is therefore obvious that general conclusions concerning the structure of the Milky Way in the direction of the centre can only be made after an extended study of the observations which have been proposed in the present programme.

The Exciting Star of Planetary Nebula NGC 3132

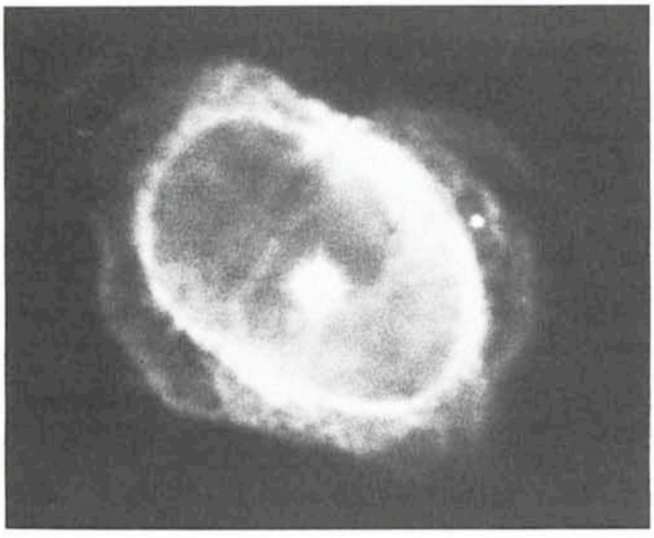


Fig. 1. — *Ultraviolet photo of NGC 3132, obtained on Feb. 14, 1977 at the 3.6 m telescope (plate no. 393). Exposure 8 minutes, IIIa-J + UG 1. The diameter of the nebula is about one arcminute.*

The term "Planetary Nebula" was coined when 18th-century astronomers discovered celestial objects that looked similar to the solar-system planets in their small-aperture telescopes. We now know that these nebulae have their origin in stellar outbursts (explosions) during which a star throws away consecutive shells of matter which afterwards expand around the central star. Spectroscopic analyses of the nebulae indicate that these stars are intense sources of ultraviolet radiation that excite the atoms in the nebulae. This is almost always confirmed when direct spectroscopic observations are made of the stars situated at the centres of the planetary nebulae: they are exceedingly hot, often the surface temperature is of the order of 100,000 °K.

A dilemma has existed for some time in the planetary nebula NGC 3132 in the constellation Pictor (Painter's easel) at R.A. = $6^h 05^m$; Decl. = -60°. Whereas the nebula indicates a temperature of about 100,000 degrees of the central star, HD 87892, this is not observed. As a matter of fact, HD 87892 is an A-type star which certainly is not hotter than 10,000 to 12,000 °K.

Recent observations by Dr. L. Kohoutek of the Hamburg Observatory, in collaboration with Dr. S. Laustsen of ESO, appear to solve this problem. A series of short exposures with the ESO 3.6 m telescope have revealed that the central star of NGC 3132 is in fact a double star and that the faint companion in all likelihood has the necessary characteristics to excite the nebula. It has a visual, apparent magnitude of about 16.5 and a luminosity 110 times that of the Sun. The star is extremely blue. It is therefore a subluminous, blue star, a stellar type that is typical for the central star of an evolved planetary nebula.

Drs. Kohoutek and Laustsen have submitted their detailed results to the journal *Astronomy and Astrophysics*.

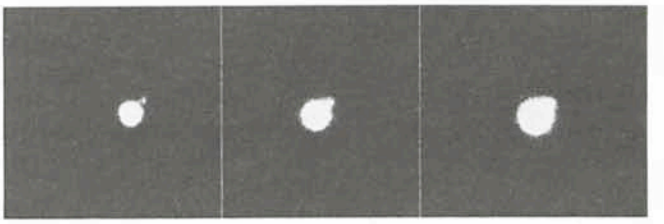


Fig. 2. — *Short-exposure images of visual binary HD 87892. 5, 10 and 20 seconds on IIIa-J + UG 1. The distance between the centres of the two components is 1.65 arcsecond.*

3.6 m Telescope: Excellent Optical Quality

The preliminary tests of the optical quality of the 3.6 m prime and Cassegrain foci optics have now been analyzed. They show that the large ESO telescope is optically nearly perfect and that the design specifications have been met, probably even significantly surpassed. The tests were carried out by the ESO Optics Section (in particular Daniel Enard, Francis Franza, Maurice Le Luyer, Patrick Monnerat and Raymond Wilson) and the present report was compiled by the leader, Dr. R. N. Wilson:

Prime Focus

In *The Messenger* No. 7 a brief summary was given of the alignment and test of the prime focus optics of the 3.6 m telescope (prime mirror with Gascoigne plate correctors). The preliminary analysis of the test results (mainly computer analysis of Hartmann test plates) was based on measurements with the modified Blink Microscope whose measuring precision is insufficient for establishing the formal energy concentration, although adequate for providing information on the important, low spatial frequency error residuals such as third-order spherical aberration, coma and astigmatism. In spite of these limitations, there was clear evidence that the specification (75 % of the geometrical energy to be within a circle of 0.4 arcsec diameter) had been met, perhaps by a clear margin.

Since this report, about 50 Hartmann plates for the prime focus have been measured on the "Galaxy" measuring machine at Herstmonceux in England. "Galaxy" has the necessary measuring precision of the order of 1μ. We consider that errors due to the photographic processing conditions (the dark-rooms were not finished at that time) and non-random (dome) turbulence giving asymmetries in some spots are probably more serious sources of error than residual measuring errors on "Galaxy".

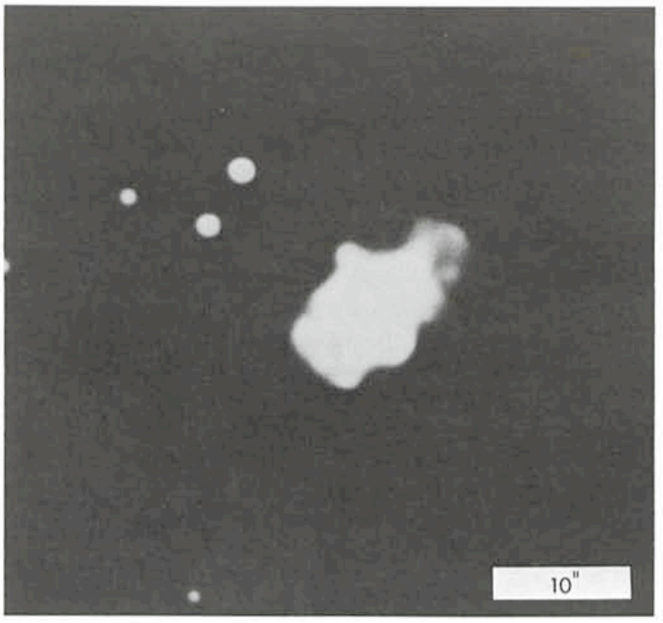
The computer analysis of the "Galaxy" measurements is now almost complete and it is hoped to produce a final report on the prime focus (with Gascoigne plates) within the next few weeks. However, it is already fully confirmed that the specification has been met with 80 % of the geometrical energy within 0.42 arcsec for the zenith position and only minor variations for the inclined telescope (between 0.46 arcsec southwards to 0.35 arcsec eastwards). These figures correspond, of course, to the state of the telescope after the removal of the very small decentring coma error present after the alignment. We believe that even this excellent result is too pessimistic; for the residual astigmatism is probably largely due to dome turbulence. Furthermore, the small residual in spherical aberration can be removed by a further axial adjustment of the corrector and any genuine residual astigmatic effects present in the primary can be removed by a small adjustment of the axial support system.

Our calculations show that removal of third-order astigmatism alone would give a geometrical energy concentration of 80 % within 0.35 arcsec diameter, while further removal of the residual spherical aberration and triangular astigmatism would give 80 % within 0.27 arcsec diameter. It should be remembered further that energy concentration values, although an apparently simple means of specification, are the most difficult values to prove formally with the Hartmann method and tend to be pessimistic because of the high spatial frequency residual statistical and systematic errors entering as background noise with a relatively large effect on the concentration values.

Our work on the prime focus had convinced us that the dome seeing was probably the major limiting factor—we wondered what the Cassegrain focus would reveal in this respect!

Cassegrain Focus

The Cassegrain focus (CF) alignment and test was a relatively simple process compared with the prime focus—it took only 3 weeks for three staff members from Geneva, compared with 11 weeks for the prime focus (PF). The main reason for this was that the PF operation represented the first use of the telescope. All the basic alignment had to be done from scratch and many general "teething problems" overcome. The initial part of the CF alignment was simply a repetition of the PF procedure—establishing a sighting line perpendicular to the δ-axis and passing through the centre of the prime mirror. (This requirement stems from the need for accessibility to the south pole and means that the δ-axis is the starting point of the optical alignment.) This sighting line was lined up with a cross-hair defining the centre of the top unit of the telescope, this cross-hair having been lined up with the centre of the prime mirror during the previous PF adjustment. On our telescope there is no possibility of translating laterally the secondary mirror within its top unit—it can only be tilted. With this single degree of freedom, only one condition can be fulfilled, and this must be imagery free from decentring coma. This is possible even if the optical axes of the primary and secondary are not exactly coincident, for a residual translation error can be compensated by a tilt. But this will incline the pointing direction (effective optical axis) so that the tolerance on perpendicularity with the δ-axis may not be met.



An interesting illustration of the use of the Cassegrain focus at the ESO 3.6 m telescope is this photo of the central part of the famous southern nebula, Eta Carinae. It shows the so-called "Homunculus" nebula surrounding the star Eta Carinae. This nebula is expanding after having been thrown out during an outburst in 1843. At that time, the apparent magnitude was brighter than −1, i.e. about the same as Sirius, but it is now around 6^m. Exposure 30 seconds on IIa-O emulsion through a GG 385 filter by S. Laustsen. Seeing around 1 arcsecond. Original scale 7 arcsec/mm. Scale on reproduction indicated by bar. North is up and east to the left.

In our present case, the initial arbitrary setting of the secondary tilt gave marked coma, easily visible on the TV screen. Hartmann analysis revealed 3.2 arcsec of coma. The tilt of the secondary is varied by 2 variable supports driven by motors and a fixed point. The position of the motor drives is given to a high precision by encoders. This arrangement is far more precise and easy to manipulate than was the PF—modifications are in progress here. The first iteration of adjustment reduced the coma to about 0.3 arcsec, the second to about 0.24 arcsec. This is about the limit for a small number of plate measurements on the Blink. More accurate centring will be possible from the "Galaxy" plate measurements. Two top unit exchanges resulted in comparable coma values. Thus the preliminary result of the reproducibility of centring after top-unit exchange seems favourable, although further confirmation will be necessary from "Galaxy" measurements.

It remained to determine the "pointing error" in perpendicularity (E-W) with the δ-axis for the Cassegrain system thus centred. This was done by a three-stage process, noting the telescope coordinates at each stage:

(a) the sighting telescope at the CF was lined on a star through the hole in the PF plate-holder,

(b) the star was then centred in the PF eyepiece,

(c) the top units were exchanged while maintaining initialization of coordinates, and the star centred in the Cassegrain plate-holder.

From the 3 sets of telescope coordinates, the CF pointing error was established as 163 arcsec in E-W. It may be necessary to improve this in future but this would involve translating the primary in its cell. At this stage, the pointing error was judged acceptable.

The remainder of the time was spent on Hartmann analysis in or near the zenith position (45 plates taken, ten plate measurements on the Blink). The operation was made difficult by two factors—repair operations on the dome severely restricting telescope and dome movement, and very bad dome turbulence giving serious disturbance of the Hartmann plate spots. The doubled optical path compared with the PF demonstrated even more cogently the present limitations of dome seeing and the need for systematic investigation as soon as time and more sophisticated test equipment are available.

In spite of this, the Blink measurements gave clear indication that the quality in the Cassegrain focus is comparable with that in the PF. The only significant aberrations detected were spherical aberration and third-order astigmatism, both with maximum wavefront slopes corresponding to 100 % of the geometrical energy in a diameter of about 0.65 arcsec, which would probably give an 80 % concentration in the order of 0.45 arcsec. The origin of the spherical aberration residual is still under investigation and may well be removable. It is believed that the astigmatism is largely caused by *dome seeing,* as in the PF. If these two defects are removed, the resulting quality should be well within the specification (75 % within 0.4 arcsec diameter). The "Galaxy" measurements will be necessary for final confirmation and will be made within the next few months.

Cassegrain Adapter

Within the framework of these tests the Cassegrain adapter (see *The Messenger* No. 8, March 1977, p. 14) was put into use and final adjustments performed. All its facilities functioned well and proved to be practical and convenient in use. Particularly impressive was the sensitivity of the TV. ESO astronomer André Muller estimated that the limiting magnitude of acquisition (centre field) was 20^m–21^m; that for guiding 19^m–20^m. Confirmation was given by the large number of guide stars found with ease, even well away from the galactic plane. The pupil observation and knife-edge on TV were extremely impressive. Above all, this provides a wonderful means of studying dome turbulence effects, perhaps by filming.

First Photos

On 19 April the Hartmann screen was removed and the first photos taken at the Cassegrain in cooperation with Svend Laustsen. In the next three nights the best plate obtained was a 2-minute exposure (guided) on a baked 2AO plate. The seeing was the best we had had, estimated at about 1 to $1^1/_2$ arcsec, and the smallest star images were about 140 μ ($\equiv$ 1.0 arcsec) and perfectly round. This, of course, is no measure of the telescope quality, which is vastly better, but provided rough confirmation with the best seeing we had.

Conclusion

We may legitimately conclude that the telescope optics is as successful in the Cassegrain as in the prime focus. Much further analysis is necessary, however, to extract the maximum potential quality—above all with respect to dome seeing.

We would like to express our acknowledgement and thanks to all those at La Silla who gave us excellent cooperation; also to our colleagues at Kitt Peak National Observatory who kindly supplied us with the basic Hartmann programme (subsequently heavily modified and extended), and to the Royal Greenwich Observatory for their excellent help and cooperation in the "Galaxy" measurements of the plates.

New Southern Dark Dust Clouds Discovered on the ESO (B) Atlas

Dr. Aage Sandqvist from the Observatory of the Stockholm University has recently compiled a list of dark dust clouds seen on the ESO (B) Atlas. It is less than ten years since radio astronomers discovered the presence of organic molecules in dark clouds of interstellar matter, and Dr. Sandqvist's list now helps observers to locate the clouds in the southern Milky Way. Radio investigations of these have already been started and will not only increase our knowledge of the distribution of the organic molecules but also give better insight into the kinematics (velocities) of the nearby interstellar matter. Dr. Sandqvist explains how this is done:

At the present time, a research group at the Stockholm Observatory is studying what is suspected to be a local, slowly expanding interstellar cloud, or rather a cloud complex of interstellar matter and relatively young stars. The expansion age of the cloud, as derived from 21-cm observations, appears to be about 60×10^6 years and its dimensions in the plane of the Galaxy of the order of 600 by 300 pc, the Solar System passing through the outer parts of the cloud. In radio spectra of the interstellar neutral hydrogen, this structure reveals itself through a narrow emission component called "Feature A" (Lindblad, Grape, Sandqvist and Schober, *Astronomy and Astrophysics* **24**, 309, 1973) with a velocity dispersion of about 2.5 km s^{-1}. It is observed over a large part of the celestial sphere and has positive radial velocity with respect to the local standard of rest almost everywhere in and near the galactic plane. Concerning young stars of early spectral type, this complex may be revealing itself through the so-called Gould's Belt.

Radio Observations of Dark Clouds

In connection with the investigation of this complex, extensive surveys of dark clouds of small angular diameters in the region of Gould's Belt have recently been undertaken by us in the 3335-MHz CH, 4830-MHz H_2CO and 1420-MHz HI lines using the 25.6 m radio telescope at Onsala, Sweden, and the 42.7 m and 91.5 m radio telescope at NRAO, Virginia, USA. These and other comprehensive surveys of molecules in interstellar dust clouds have depended heavily upon Lynds' Catalogue of Dark Nebulae (*Astrophysical Journal Supplement* **7**, 1, 1962) as a source for clouds. The dust clouds thus surveyed are

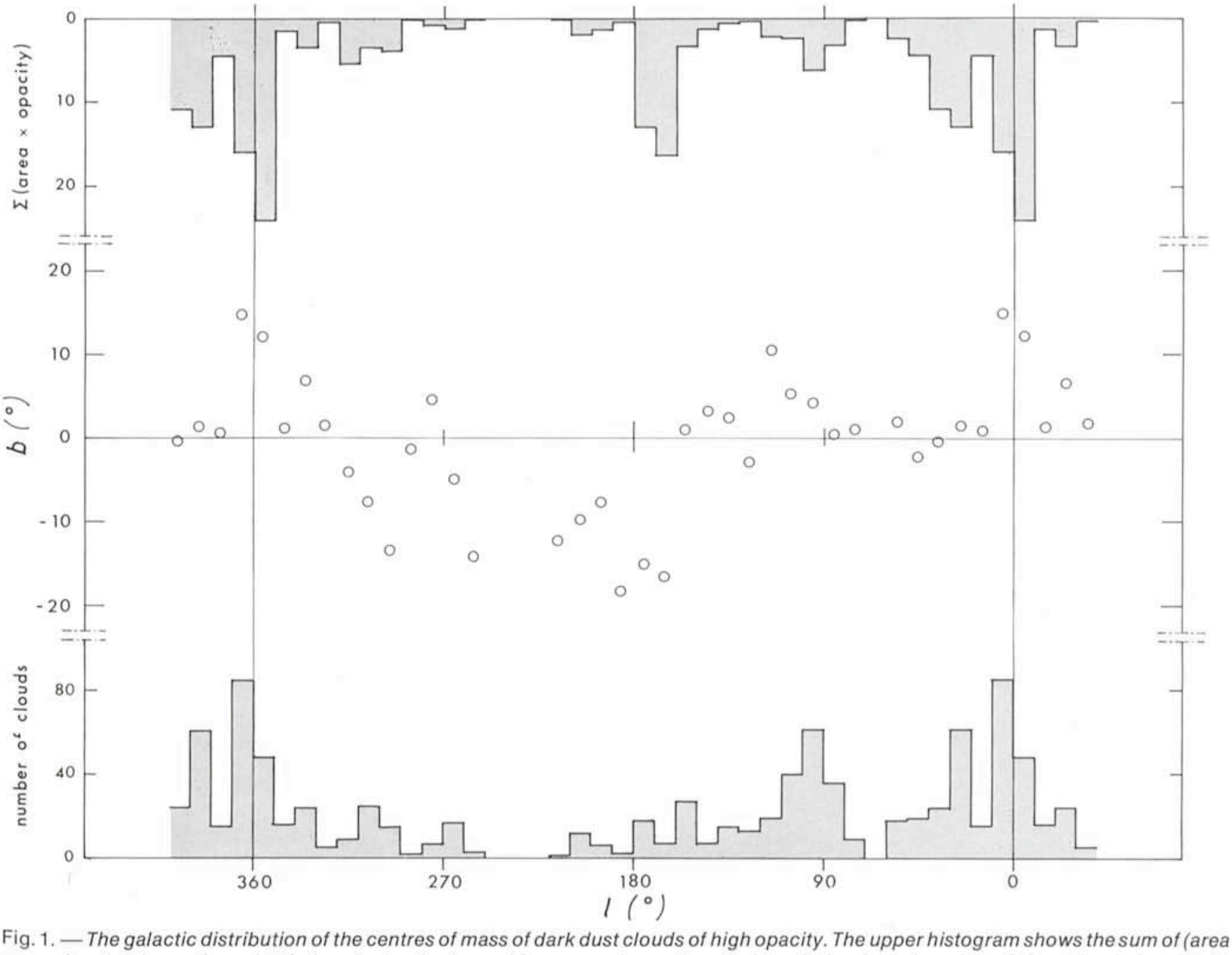


Fig. 1. — *The galactic distribution of the centres of mass of dark dust clouds of high opacity. The upper histogram shows the sum of (area x opacity class) vrs. the galactic longitude; the lower histogram shows the number of clouds as function of the galactic longitude.*

limited to the galactic longitude range of 350°–0°–240° by the mere limitation of sky coverage in declination ($\delta >$ –33°) of the plates in the National Geographic Society-Palomar Observatory Sky Survey from which Lynds catalogued the clouds.

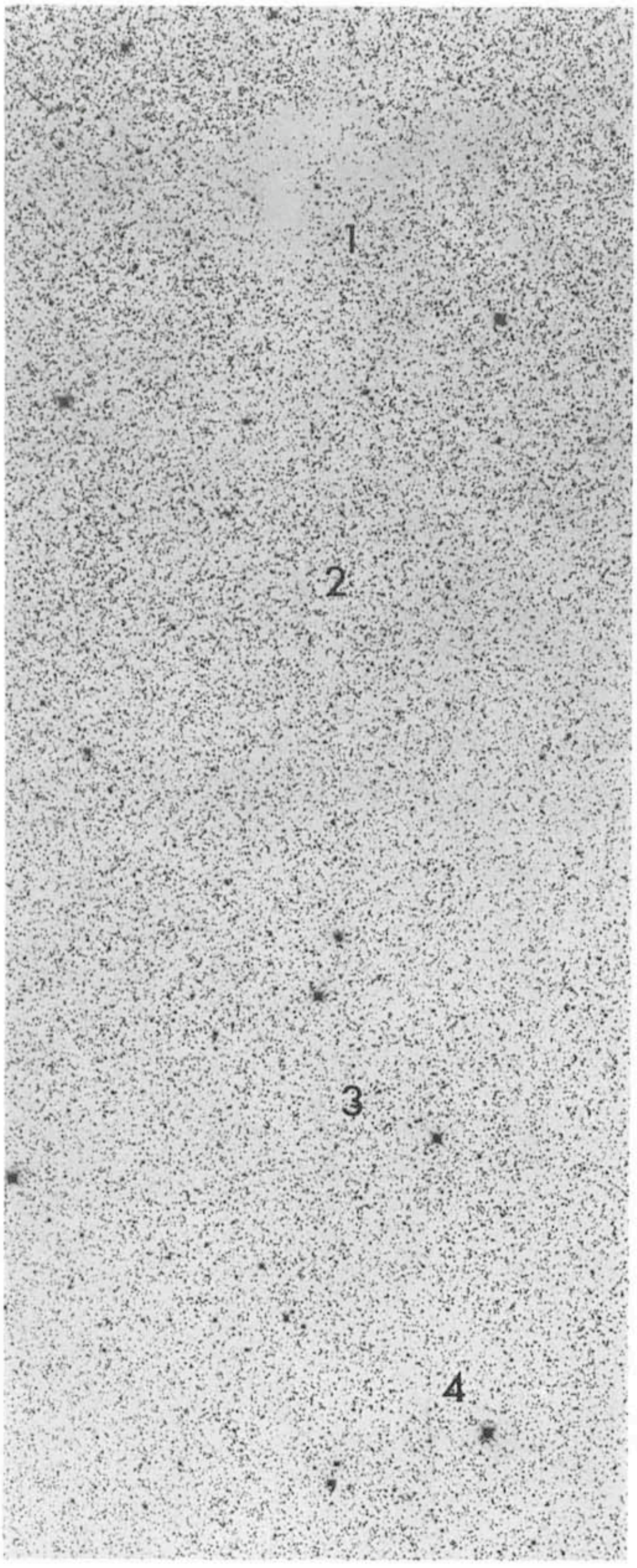


Fig. 2. — *Four new dark dust clouds discovered in ESO (B) Atlas field no. 208. No. 1 is an extended dark nebula and nos. 2 to 4 are so-called "cometary" globules. They are seen to the left of the numbers.*

In a project purporting to extend the sky coverage to $\delta >$ –46° we have surveyed the Whiteoak southern extension to the Palomar Sky Atlas and have presented a catalogue (Sandqvist and Lindroos, *Astronomy and Astrophysics*, **53,** 179, 1976) of 42 dark dust clouds of opacity classes ranging from 4 to 6. The reason for limiting the survey to high opacity clouds was that these clouds were subsequently observed in the 6-cm line of the formaldehyde molecule (H_2CO) which favours clouds of high opacity. This has extended the galactic longitude range of clouds surveyed for H_2CO to 336°–0°–271° which, however, still leaves a large part of the fourth quadrant unobserved. This quadrant is of great importance for the study of the kinematics of the local interstellar matter since it is here that different models predict the strongest kinematical divergence from each other (e.g. Lindblad et al. 1973; Burton and Bania, *Astronomy and Astrophysics* **34**, 75, 1974).

Dark Clouds on the ESO Plates

When the ESO (B) Atlas made the remainder of the southern sky accessible for a similar cloud survey, a complementary catalogue (Sandqvist, *Astronomy and Astrophysics,* **57,** 467, 1977) of 95 southern dark dust clouds was compiled with future molecular line observations from the southern hemisphere in mind. In order to estimate the positions of the centres of mass of all the darkest clouds along the *complete* Milky Way band, the mean galactic latitude, weighted by the area and the opacity class, of the clouds in intervals of 10° in longitude were computed. All Lynds' clouds of opacity class 5 and 6, together with all the clouds in our two catalogues were used for this analysis. The result is shown in Figure 1, which also contains histograms of the number of clouds and the sum of the (area x opacity class) for the clouds in longitude intervals of 10° versus galactic longitude.

Lynds found a tendency for the darkest clouds to lie slightly above the galactic plane and not to exhibit any association with the inclined Gould's Belt of bright stars. It is obvious from Figure 1 that this conclusion can no longer stand after the southern clouds have been included in the sample. The distribution of the darkest clouds clearly shows a preference towards the general direction of the galactic centre, but it can easily be seen that, whereas the clouds in the longitude range 320°–0°–120° do indeed lie mainly at *positive* latitudes, there is a strong cloud preference for *negative* latitudes in the longitude range 120°–320°. This reflects a behaviour similar to that of Gould's Belt which is not surprising since Lindblad et al. (1973) have already suggested that some of the dark clouds, the local neutral hydrogen and the Gould's Belt of early-type stars may be related. We have strengthened this suggestion by obtaining kinematic data for some of the clouds in the fourth galactic quadrant, observing them in the 6-cm H_2CO line, and further molecular line surveys of remaining southern dark dust clouds will soon be completed at the Parkes radio observatory in Australia, so that kinematic studies can be applied to the full system of the local interstellar matter.

Cometary Globules

Among the new clouds discovered on the ESO plates were four more cometary globules (Sandqvist, *Monthly Notices of the Royal Astronomical Society,* **177,** 69P, 1976), three of which are shown in Figure 2 together with a bright dark nebula. The cometary globules are "comet-like" objects with compact dusty heads, almost completely opaque but with bright leading rims and faintly luminous tails, found predominantly in the outskirts of the Gum Nebula. The tails generally point away from the centre and, in the case shown in Figure 2, the cometary globules lie almost along a straight line intersecting the bright dark nebula, possibly suggesting that they have been torn away from it by the activity in the central region of the Gum Nebula.

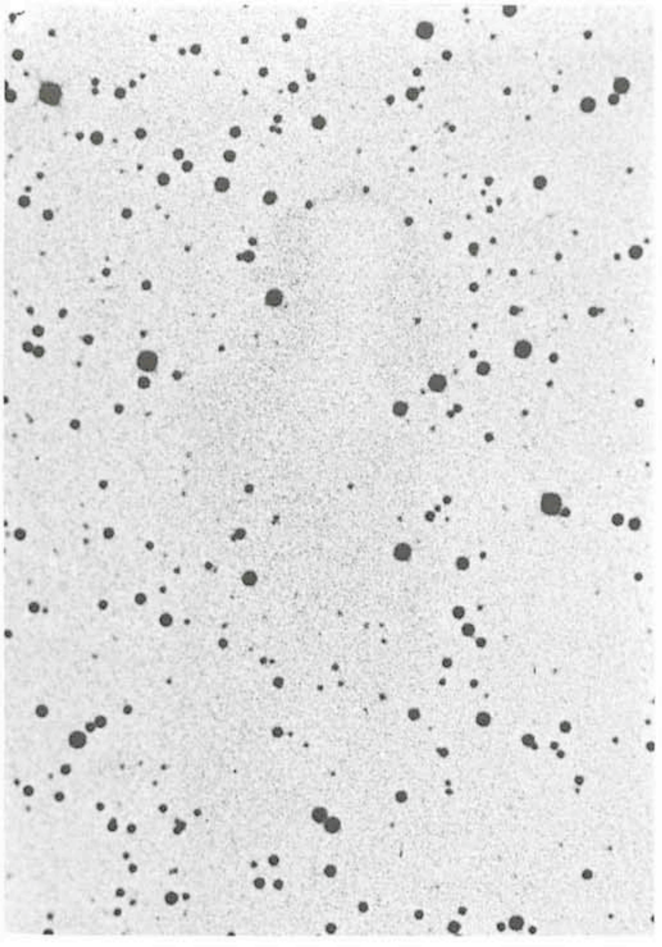


Fig. 3. — *An enlargement of cometary globule no. 2 from figure 2, Note the complete absence of stars inside the area of the globule, indicating at the same time its closeness (no stars between us and the globule) and its dense structure (no stars behind can shine through).*

ANNOUNCEMENT OF AN ESO CONFERENCE

"Optical Telescopes of the Future"

The European Southern Observatory is organizing an International Conference on the subject "OPTICAL TELESCOPES OF THE FUTURE", to be held in Geneva on the premises of CERN in the period 12-16 December 1977.

The preliminary programme of the Conference includes the following topics and speakers:

1. General Introduction (L. Woltjer – ESO; A. B. Meinel – Tucson).
2. Conventional Large Telescopes (R. Wilson – ESO; W. Richter – ESO).
3. Incoherent Arrays and Multi-mirror Telescopes (M. Disney – Herstmonceux; P. Strittmatter – Tucson; R. Angel – Tucson; D. N. Hall – Kitt Peak; E. H. Richardson – Victoria).
4. Coherent Arrays and Interferometers (A. Labeyrie – Meudon; R. Hanbury-Brown – Sydney; R. Ekers – Groningen; C. Townes – Berkeley).
5. Image Processing and Live Optics (F. Dyson – Princeton; A. Labeyrie – Meudon; A. Lohmann and G. Weigelt – Erlangen; J. W. Hardy – ITEK Corporation).
6. Astronomical Implications (J. Greenstein – Pasadena).

Scientists wishing to participate and eventually present a short contributed paper in any of the above sessions are invited to write and to send an abstract (10-20 lines) of their proposed contribution to

R. N. Wilson
ESO-TP Division
c/o CERN
CH-1211 Geneva 23
Switzerland

The deadline for receiving abstracts is 15 October 1977.

PERSONNEL MOVEMENTS

(A) Staff

ARRIVALS

Geneva

Instrument Development Group: Philippe ROSSIGNOL (French), systems analyst/programmer, 17.10.1977.
Scientific Group: Renate TRÖNDLE (German), secretary, 16.9.1977.

TRANSFERS

Svend LAUSTSEN (Danish), senior astronomer; from Chile to Geneva Scientific Group, 1.8.1977.
Fernand SIMON (Belgian) designer/draughtsman (mech.); from Chile to Geneva Engineering Group, 1.10.1977.

(B) Paid Associates – Fellows – Coopérants

ARRIVALS

Geneva

Scientific Group: Irena J. SEMENIUK (Polish), paid associate, 1.10.1977.
Massimo TARENGHI (Italian), fellow, 1.10.1977.
Robert A. E. FOSBURY (British), fellow, 21.11.1977.
Ivan R. KING (American), scientific associate, August 1977.

Chile

Astronomy: Christian BAREAU (French), coopérant, October 1977.

DEPARTURES

Geneva

Scientific Group: Evangelia O. ATHANASSOULA (Greek), paid associate, 31.8.1977.
Pierre TURON-LACARRIEU (French), fellow, 30.9.1977.
George CONTOPOULOS (Greek), paid associate, 15.9.1977.

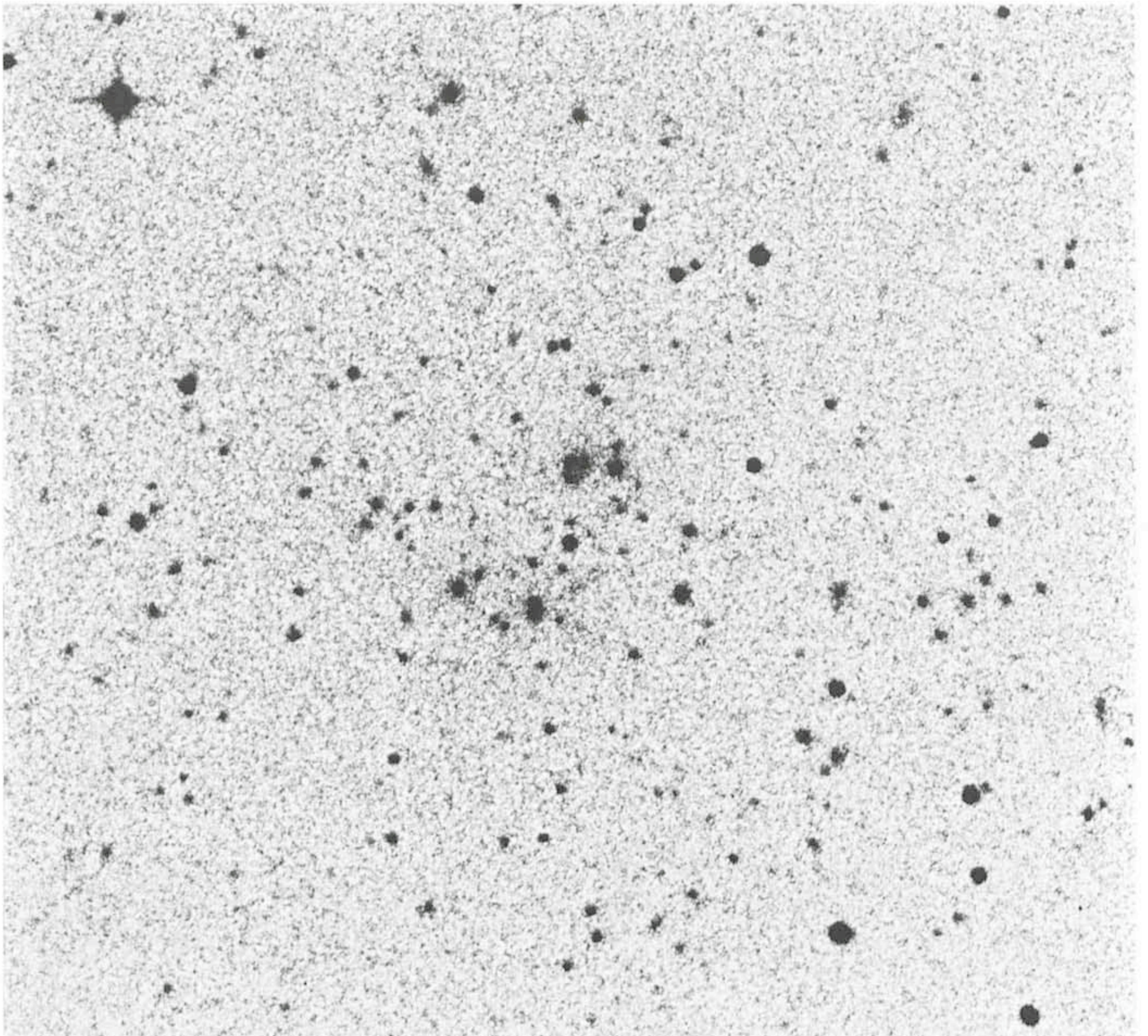
New Southern Groups and Clusters of Galaxies

The first deep photographic atlas of the southern sky, the ESO (B) Atlas, is now virtually complete. It has already been extensively used by many southern observers, and lists of various objects are being compiled. Drs. Alan Duus and Barry Newell of the Mount Stromlo and Siding Spring Observatory in Australia have identified a large number of new clusters of galaxies which will no doubt soon be studied in closer detail. Excluding the quasars, faint galaxy clusters are the most distant known objects in the universe and are therefore of great importance for the study of its large-scale structure. Drs. Duus and Newell report:

We have undertaken a survey of a limited region of the southern sky to obtain a finding list of clusters of galaxies. We chose 97 high galactic latitude ($|b^{II}| > 20°$) fields from the ESO (B) Survey, and from these located 770 groups and clusters, of which no less than 710 proved to be new identifications.

Clusters were examined visually, using our film copies of the ESO (B) Atlas and a x 7 eyepiece, and classified on a system similar to that described by Zwicky, Herzog and Wild (1961). The accompanying photograph shows STR 2232–380, a newly-identified cluster. It is classified as compact, with ~200 members and is extremely distant.

Cluster coordinates (α, δ) were determined with respect to a grid of standard stars selected from the SAO catalogue. Our catalogue includes clusters and groups, with $\delta < -27°$, previously identified by de Vaucouleurs (1956, 1975), Klemola (1969), Snow (1970), Sersic (1974), Rose (1976) and Sandage (1976).



The new, extremely distant cluster of galaxies, STR 2232–380, reproduced from the ESO (B) survey plate (60 min, IIa-0 + GG 385). Note in particular the central condensation of elliptical galaxies which leads to classifying the cluster as "compact".

Our catalogue is not intended for use in statistical studies. Rather it is meant to provide a convenient finding list of southern groups and clusters that cover a wide range in distance, richness and morphological type, and that are distributed over the full range of right ascension. The catalogue will be published in the *Ap. J. Suppl.*, October 1977.

Duus is now undertaking a programme of investigation into the closest southern clusters, commencing with Fornax (STR 0321-374) and Abell 1060 (STR 1034-272). Using photoelectric and photographic photometry he will be examining in particular the early-type galaxies with a view to determining the luminosity (mass) dependence of their properties. The investigation will then be extended to some of the more distant clusters identified in this survey.

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Sersic, J. L. 1974 *Ap. Space Sci.*, 28, 365.

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With great pain we have received the notice that

Bent Grønbech Jørgensen

died on June 7, 1977, only 29 years old, from a heart failure, with no prior illness.

Bent is well known on La Silla, where he spent most of his time between February 1972 and December 1974, carrying out many thousands of photoelectric observations with the Danish 50 cm telescope. In his function as "Danish Resident Astronomer" and part-time ESO staff member, he was also responsible for the maintenance of the telescope and its instrumentation and the introduction of visiting astronomers to the Danish telescope.

These fruitful years on La Silla resulted in important scientific work such as the "Grønbech-Olsen Catalogue" of complete uvbyβ photometry of southern bright stars, and a long series of papers on eclipsing binaries recently published in *Astronomy and Astrophysics.*

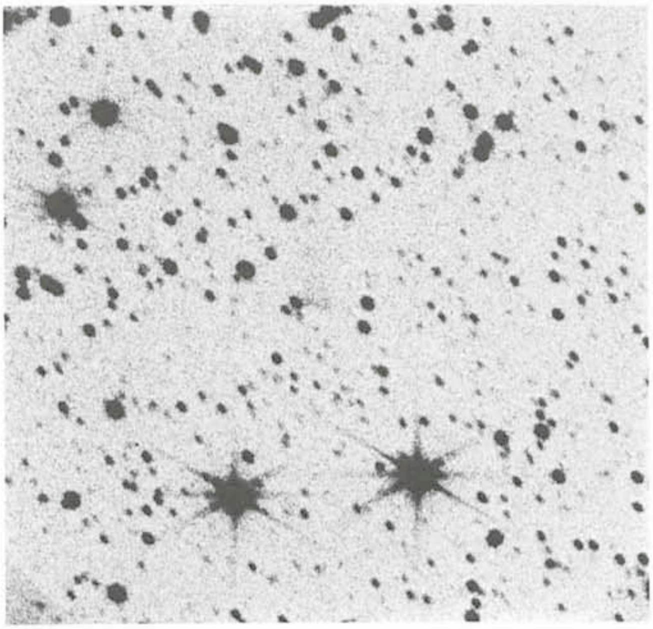
Apart from astronomy, his interests and activities covered many other fields. He participated in research programmes in geology at the Copenhagen University. He was also enthusiastic at archaeology and adventurous-like travels, visiting all five continents in the course of his numerous trips. During the last year of his life he went back to university and began to study computer science.

Bent left a scientific work of permanent value. More than this, however, his friends will remember his quiet but energetic personality, the enthusiasm with which he represented his ideas, often new and unconventional, his way of thinking without compromises and weaknesses which finally is the origin of his scientific success, but which, on the other hand, signified for his friends a person of absolute confidence, reliability and human quality.

All of us who got to know him closely will keep his memory as a great person and friend.

Nikolaus Vogt

La Silla, July 1977.



Comet Schuster

It is now more than one year and a half since Comet Schuster (1975 II) was discovered on an ESO Schmidt plate. It still holds the record of having the largest known perihel distance, about 1,030 million kilometres, and after having passed through the perihel on January 15, 1975, it now recedes slowly in a slightly hyperbolic (open) orbit, according to the latest orbital computations. Towards the end of 1977, it "crosses" the orbit of Saturn, and due to the comet's exceptional size, it should be possible to follow it for another several years.

The present photo was made low in the evening sky on May 13, 1977 with the ESO Schmidt telescope (observer: the discoverer). One still sees a faint tail, extending upwards from the comet trail. The stellar images were elongated because of differential refraction during the 1-hour exposure, an effect that is unavoidable when observing close to the horizon. The distance from the Earth was almost exactly 1,300 million kilometres and the apparent magnitude ot the comet head was 18.5.

Visiting Astronomers

(October 1, 1977—April 1, 1978)

Observing time has now been allocated for period 20 (October 1, 1977 to April 1, 1978). The demand for telescope time was again much greater than the time actually available.

This abbreviated 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 at request from ESO/Munich.

3.6 m Telescope

Oct. 1977:	van Agt, Lindblad, Swings, Wamsteker/Dennefeld.
Nov. 1977:	Dennefeld, Maurice/Prévot/Audouze, Tarenghi.
Dec. 1977:	Fehrenbach/Andrillat, Schnur, Swings/Wamsteker/Surdej, Ulrich.
Jan. 1978:	Brahic, Crane, West, Westerlund/Olander, Westerlund/Ekman/Lauberts/Bergvall, Appenzeller.
Feb. 1978:	Appenzeller, Georgelin/Comte, Lelièvre/Wlérick.
March 1978:	Gahm, Laustsen, van Paradijs/van den Heuvel, Véron, Schultz/Kreysa.

The Calibration Equipment of the ESO Schmidt Telescope

Some time ago, two calibrating devices of completely new design were installed in the ESO Schmidt telescope. Invented by ESO astronomer Dr. André Muller, they permit simultaneous exposure of the sky and the calibration marks in the telescope. This greatly increases the accuracy of the calibration of the photographic plate, a problem that has always worried astronomers. Dr. Muller explains how it works:

Some time ago the ESO Schmidt telescope was equipped with a calibrating device specially designed to produce calibration marks in exactly the same way as the stars and galaxies are acquired on the photographic plate. The philosophy behind the design is that the most reliable calibration is obtained if done simultaneously with the sky exposure, i.e. simultaneous and equal exposure time for sky and calibration marks.

Two projectors were constructed and mounted inside the telescope tube, as shown in Figure 1, in such a way that the projectors cause no light obstruction for the entering star and sky light. The calibration marks are projected on the sky background at the east and the west edge of the photographic plate.

The design of the projectors is shown in Figure 2. The light source (107) is chosen as to match as well as possible the required colour characteristic. The light passes through two different quartz windows (106). The size of the front window is matched by means of a diaphragm (25) with the diameter of the projecting lens (102) in order to avoid light scatter inside the projector tube. The lens (105) images the diaphragm (25) on lens (102) which projects an image of a step-wedge (104), placed immediately in front of lens (105), on the photographic plate. The intensity of the light passing through diaphragm (25) is variable and depends on the exposure time of the photographic plate. In order to keep the colour characteristic of the light constant for different intensities, the light source (107) can be shifted along the axis (30) of the projector tube over a range of 1 to 12 cm from the quartz windows (106) covering an interval of nearly 5.5 magnitudes which has proved to be amply sufficient for the used range of exposure times.

The homogeneity of the light spot on the photographic plate was tested by removing the step wedge and measuring the density on the photographic plate of the image of the lens (105). Density variations of 0.01 were measured over the full size of the image which is 9.4 times larger than the actual surface used for the projection of the step-

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1.52 m Spectrographic Telescope

Oct. 1977:	Breysacher/Azzopardi, Ahlin, Foy, van Paradijs/van den Heuvel, Materne/Tarenghi/Chincarini, Schmidt-Kaler/Kühn/Feitzinger/Reinhardt, Imbert.
Nov. 1977:	Imbert, Wamsteker, van Paradijs/van den Heuvel, Bergvall/Lauberts/Westerlund/Ekman, Dennefeld/D'Odorico, Kohoutek, Surdej/Breysacher, Sterken/Jerzykiewicz, Lacoarret.
Dec. 197	Lacoarret, Melnick, Dennefeld, Dennefeld/D'Odorico, Mauder, Klutz, Pakull.
Jan. 1978:	Pakull, Breysacher/Muller/Schuster/West, Schnur, Kunth, Westerlund/Olander, Seggewiss/Maitzen, Breysacher/Westerlund, Dravins.
Feb. 1978:	Dravins, Ardeberg/Lyngå, Georgelin/Comte, Breysacher/Muller/Schuster/West, Reimers, Gahm, Danks.
March 1978:	Danks, de Loore, Wamsteker, Breysacher/Westerlund, Andersen, Ahlin, Hunger/Kudritzki, Surdej.

1 m Photometric Telescope

Oct.	Thé/Staller, Alcaíno, Wamsteker/Schober, Epchtein/Turon.
Nov. 1977:	Vigneau, Vogt, Bergvall/Lauberts/Westerlund/Ekman, Wamsteker.
Dec. 1977:	Crane/Dennefeld, Lequeux/Mianes/Vigroux, Muller/Surdej/Schuster/West, Wamsteker, Salinari, Mauder.
Jan. 1978:	Mauder, Crane, Wlérick, Schnur, Westerlund/Olander, Pakull, Lub, Schröder.
Feb. 1978:	Schröder, Schnur, Lelièvre, Vogt, Knoechel, Gahm.
March 1978:	Gahm, Möllenhoff, Dennefeld/Materne, Adam, Wamsteker/Schober, Wamsteker, Sherwood/Arnold.

50 cm ESO Photometric Telescope

Oct. 1977:	Bouchet, Vogt, Bouchet, Wamsteker/Schober, Duerbeck.
Nov. 1977:	Duerbeck, Vogt, Duerbeck, Kohoutek.
Dec. 1977:	Kohoutek, Surdej, Vogt, Surdej.
Jan. 1978:	Surdej, Vogt, Pakull, Seggewiss/Maitzen, Haug.
Feb. 1978:	Haug, Knoechel, de Loore.
March 1978:	de Loore, Vogt, Bastiaansen.

GPO — 40 cm Astrograph

Oct. 1977:	Azzopardi/Bijaoui, Blaauw/West, Azzopardi/Bijaoui.
Nov. 1977:	Blaauw/West, West/Muller/Schuster/Surdej, Martin.
Dec. 1977:	Martin, West/Muller/Schuster/Surdej, Martin.
Jan. 1978:	West/Muller/Schuster/Surdej, Blaauw/West, Gieseking.
Feb. 1978:	Zeuge, Blaauw/West, Gieseking, Azzopardi.
March 1978:	Azzopardi, Blaauw/West, Gieseking, Azzopardi.

50 cm Danish Telescope

Nov. 1977:	Renson, Sterken/Jerzykiewicz.
Dec. 1977:	Sterken/Jerzykiewicz, Heck, Klutz, Heck.
Jan. 1978:	Heck.

Do not forget ...

... that applications for observing time during period 21 (April 1, 1978 to October 1, 1978) must be sent to ESO-Munich **before October 15, 1977.** It has been decided that late applications will **not** be considered this time.

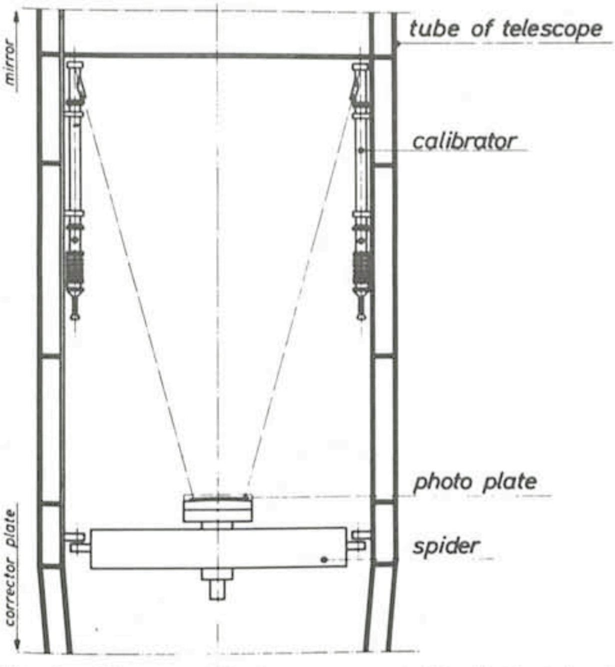


Fig. 1. — *The two calibrators are mounted inside the tube of the Schmidt telescope and projects calibration marks on the photographic plate.*

wedge. This is fully acceptable for photometry on Schmidt plates. The same exposures were used to measure the existence of scattered light. Density variations in the wide surrounding of the calibration marks were of the order of 0.01 and no systematic density pattern could be found, proving that no disturbing light scatter occurs.

As the projector is mounted just outside the actual limiting light beam of the telescope, the projection angle is slightly larger than the angle of incidence of the star light at the edge of the plate. This causes an image distortion resulting in a magnitude difference over the height of one calibration mark of the order of 0.003 which is negligible. The projectors are dust-proof protected at the front side by a quartz window (103) which is mounted rimless, allowing effective and easy regular cleaning. The mounting of the mirror (101) which reflects the image to the plate is very delicate because the slightest stress on this mirror causes unacceptable image distortion. The mirror position can be adjusted to enable the positioning of the calibration marks at the plate edges. Figure 3 shows one of the two calibration marks copied from an original plate. The details in the dense parts do not show up well in the reproduction.

ESO Fellowships 1978–1979

The European Southern Observatory (ESO) intends to award up to six fellowships tenable in the ESO Scientific-Technical Centre which is presently located on the grounds of CERN in Geneva.

The main goals of the Centre are as follows:

- to carry out a programme of development of auxiliary instrumentation for the large telescope;
- to make studies in observational and theoretical astrophysics so that the observing facilities can be used in an optimal way;
- to foster cooperation in astronomy and astrophysics in Europe.

Most of the scientists in the Centre come from the Member States of ESO, but some are from other countries. At present, the Member States of ESO are: Belgium, Denmark, the Federal Republic of Germany, France, the Netherlands and Sweden. In addition to regular staff members, the Centre comprises research associates and post-doctoral fellows.

ESO facilities include the La Silla Observatory in Chile where telescopes with apertures of 1 m and 1.5 m as well as a 1 m Schmidt telescope have been in operation for some time, while a 3.6 m telescope is becoming operational in 1977. The ESO Sky Atlas Laboratory is located in Geneva. A CDC 7600 computer system is available at CERN.

Applicants should have a university degree, preferably a doctorate. The basic monthly salary will be not less than SFr 3076. The fellowships are granted for one year, beginning about September 1978, with reasonable possibilities for renewal for a second year. Applications should be submitted to ESO not later than 31 December 1977. Applicants will be notified by the end of February 1978. The ESO Fellowship Application form should be used and be accompanied by a list of publications. In addition, three letters of recommendation should be obtained from persons familiar with the scientific work of the applicant. These letters should reach ESO not later than 31 December 1977. Late applications may be considered in exceptional circumstances.

Enquiries, requests for application forms and applications should be addressed to

European Southern Observatory
Fellowship Programme
Schleissheimer Str. 17
D-8046 GARCHING b. München
Federal Republic of Germany
Telephone (089) 3204041

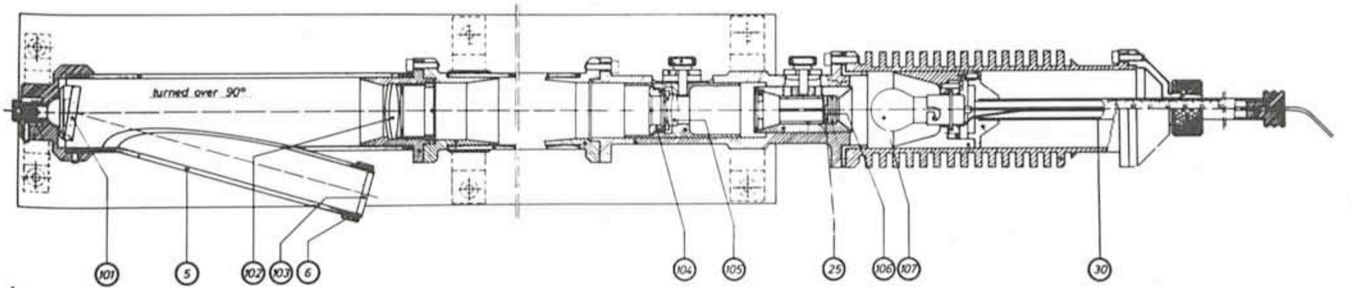
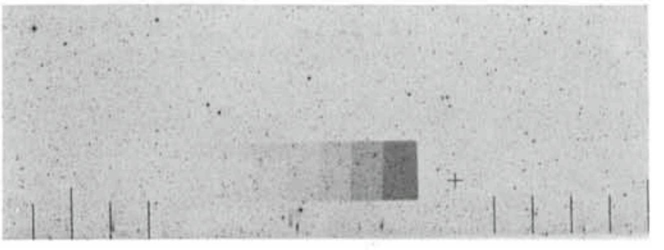


Fig. 2. — *The design of the calibration device. Details are explained in the text.*

Fig. 3. — *Example of calibration marks on an ESO Schmidt plate. Exposure 90 minutes, IIIa-F (127-04) + RG 630. Two such marks are imprinted on each plate. The present wedge has only seven steps and will be replaced by another with fourteen steps, in order to improve the calibration accuracy. The weakest step is less than 0.01 density above sky background.*



The Revised 3C Catalogue of Radio Sources

P. Véron

Dr. Philippe Véron of the Paris Observatory is well known for his work on the optical identification of radio sources. He is presently spending a two-year period with the ESO Scientific Group in Geneva, together with his charming astronomer-wife, Dr. Mira Véron. In this article, Dr. Véron discusses the importance of optical observations of extragalactic radio sources for determining the type of universe we live in and summarizes the present status of the 3CR radio survey.

In 1935, extraterrestrial radio waves were discovered by Jansky. The first discrete radio source was discovered in 1946, in Cygnus, by Hey, Parsons and Philipps. A few more were discovered in the following years by Bolton and his co-workers who in 1949 were able to identify Virgo A and Centaurus A with two giant elliptical galaxies: NGC 4486 and NGC 5128. It became obvious that a systematic survey of the sky should be undertaken to study this new population of extragalactic radio sources.

After a preliminary survey, known as 1C, of about 50 discrete sources, a large interferometer was constructed in Cambridge, consisting of four parabolic cylinders. With this telescope, at $\lambda = 3.7$ m ($\nu = 81$ MHz), Ryle and his colleagues attempted in 1955 an extensive survey of radio sources, labelled 2C.

In Sydney, a survey using a different type of radio telescope, but at the same wavelength, was at this time conducted by Mills and his group. Part of the sky was surveyed both in England and in Australia. The two lists of sources were compared, and the disagreement was almost complete; hardly any of the individual sources corresponded. The reason for this disagreement was confusion which mainly affected the Cambridge survey. Confusion arises from the limited angular resolving power of radio telescopes; if the sky density of sources is large, the probability for two or more sources to appear in the same beam or field of view of the telescope will also be large, producing a number of spurious sources having an apparent flux density larger than the limit of the survey.

It was eventually realized that confusion is a serious problem if the number of sources listed exceeds about one source per 25 primary beam areas. With the same interferometer adapted to a shorter wavelength, $\lambda = 1.9$ m ($\nu = 159$ MHz), in order to reduce the beam area, a new and more reliable Cambridge list of 471 sources, the 3C Catalogue, was published in 1959.

New observations at $\lambda = 1.7$ m ($\nu = 178$ MHz) led in 1962 to the publication of the "revised 3C Catalogue of radio sources" (3CR). It is a survey of the sky north of declination $\delta = -5°$, including all point sources with a flux density greater than 9.0 Jy (1 Jy $= 10^{-26}$ w m^{-2} Hz^{-1}; Jy = Jansky).

The 3CR catalogue was the first reliable list of extragalactic sources to have been published. Among the 328 sources contained in this list, 29 are galactic: HII regions or supernova remnants.

In 1951, Smith's very accurate radio position for Cygnus A enabled Baade and Minkowski to identify this source with a faint galaxy of great radial velocity ($V_r = 16{,}800$ km/sec, $z = 0.057$). The discovery of this object had a great importance because it revealed that a radio source similar to Cygnus A, but with a flux density of 9 Jy (the limit of the 3CR catalogue), would be at a very large distance ($z = 1.8$ if $q_0 = 1.0$, $z = 1.2$ if $q_0 = 0.0$); i.e. a deep radio survey would contain cosmological information.

If the number density of radio sources is uniform and the space-time geometry Euclidean, the number of sources N with power flux density greater than S should be inversely proportional to $S^{1.5}$; i.e. a logarithmic graph of N against S would have a slope of -1.5. In an expanding universe, the slope can only be larger than this value. Scott and Ryle in 1961 showed that the logN/logS curve for the 3CR sources has a slope of $-1.80 \pm .12$, indicating an excess of faint sources which may be most easily explained by assuming an evolution with time of the radio sources; the density of the strongest of them decreasing as time increases.

A large number of deeper surveys, covering a large range of wavelengths, have been published since 1962; but the 3CR contains the strongest sources which are the easiest to observe, and it is the oldest, so after 15 years it is by far the best known sample of radio sources.

Most of the 3CR sources have been mapped with a very high resolution, and their radio spectra are accurately known over a large interval of frequencies. For the 255 sources outside the galactic plane, the identifications with optical objects, quasars or galaxies, most of them giant ellipticals, are complete to the limit of the Palomar Sky Survey (about 20 mag), following the initial pioneering work of Véron and Wyndham.

Moreover, many of the fields which are still empty on the Sky Survey have been photographed with large telescopes by Gunn, Kristian, Longair, Sandage, Spinrad, Wlérick and others, allowing identifications to be made with objects as faint as the 23rd magnitude. Recently, Longair und Gunn have shown that at the limit of ~23.5 mag, only 5 per cent of the sources in a large region of the sky were still unidentified. This fraction will obviously be larger in a deeper radio survey.

A large number of redshifts (163) have been measured for these identifications. In 1960, Minkowski measured the redshift of 3C 295.0, a very faint elliptical galaxy with $V = 20.1$ with the Palomar 5 m telescope. From two spectrograms of the galaxy, totalling 13.5 hours of exposure time, he found $z = 0.46$. He would not have been successful if the galaxy had not had a very bright [OII] λ 3727 emission line.

This was for many years the record redshift for a galaxy, but now thanks to the effort of Kristian, Sandage, Westphal, Spinrad and Smith, using new linear detectors, eight additional redshifts have been measured larger than this value, reaching $z = .81$ for 3C 265.0, for galaxies as faint as $V = 21.0$. All these galaxies have emission lines in their spectra.

We may hope that in the near future the redshifts will have been measured for all 3CR galaxies brighter than $V = 20.5$ (about 20 remaining). About 70 sources would then be left unidentified, or identified with galaxies fainter than $V = 20.5$. The Space Telescope may enable us to identify and measure all of these objects. Then, for the first time, we will have a complete sample of radio sources, completely identified. This is extremely important as it will then be possible to measure directly the time evolution of the luminosity function of radio galaxies, and perhaps to put an upper limit to the value of the acceleration parameter q_0, as we expect a larger number of large redshifts for $q_0 = 1.0$ for instance, than for $q_0 = 0$.

But before reaching any conclusion from the analysis of the 3CR Catalogue, we have to ask ourselves the following question: is this sample really complete and unbiased? A recent study has shown that this is not the case. The antenna beam width of the Cambridge radio telescope used for preparing this survey was 13'.6 EW and 4°.6 NS. This beam width is so wide that some 3CR sources may still be affected by confusion of nearby sources. This could fortuitously raise the combined flux of the 3CR source and the confusing source above the catalogue limit of 9.0 Jy.

The more recent 4C catalogue is complete to 2.0 Jy (at the same frequency of 178 MHz). A search for all 4C sources in the neighbourhood of each 3CR source and a careful study of their radio spectrum (higher frequency measurements are usually not affected by confusion) have led to the rejection of 59 sources, whose flux density is lower than 9.0 Jy. In addition, 9 new sources were added which do not appear in the original 3CR because of resolution effects. Their angular size is so large that their peak flux density measured with the 3CR instrument was below the limit of 9 Jy. The corrected 3CR sample then contains only 205 sources outside the galactic plane. The slope of the logN/logS curve for the original 3CR is −1.80; for the new sample it is only −1.70, which makes the necessary time evolution somewhat less strong than anticipated, the excess of faint sources being smaller.

In conclusion, we may say that because of the tremendous amount of data accumulated in fifteen years on the 3CR sources, and although a large amount of effort and telescope time is still needed before the distance of all sources in the corrected 3CR sample is known, this is certainly a worth-while project as it will give us a better knowledge of the evolution of radio sources and perhaps some limitation on the possible value of the acceleration parameter q_0.

We must add that some more radio data are needed because for a few sources (like 3C 105.0, 3C 300.1, 3C 306.1, 4C −01.04, 4C 73.08, the last two not appearing in the original 3CR) the radio structure and position are not known well enough to make an unambiguous identification.

As an example, let us take the case of 3C 321.0. For many years, it was believed to be a single source in an empty field, but in 1974, Högbom and Carlsson showed with the Westerbork radio telescope that in fact it is an asymmetrical triple, the central component coinciding with a 16th-mag galaxy at z = 0.1.

Obviously, the study of deeper or higher frequency surveys should not be neglected as they will bring complementary and very useful information; but still a study, as complete as possible, of this limited sample of 205 extragalactic sources should have a high priority.

STATE OF IDENTIFICATIONS IN THE ORIGINAL AND IN THE CORRECTED 3CR SAMPLE

Total number of sources	Original 3CR		Corrected sample	
$\|b\| \geqslant 10°$	255	%	205	%
QSS (no z)	55 (7)	21	45 (4)	22
Galaxies with z < .200 (no z)	77 (2)	30	70 (3)	35
Galaxies with measured z > .200	40	16	29	14
Galaxies without z, m_{pg} < 21.0	19	8	14	7
Galaxies without z, $m_{pg} \geqslant 21.0$	20	7	16	7
Empty fields	40	16	27	13
Absorbed fields	4	1.5	4	2

Two New Stellar Systems Detected on ESO Schmidt Plates

Last year, two new irregular dwarf galaxies were discovered on ESO Schmidt plates in the constellations Phoenix and Sculptor (*Messenger* No. 7, December 1976). Now, continued inspection of plates taken for the ESO (B) Survey has revealed another two, hitherto unknown stellar systems in Eridanus (River Eridanus) and in Sagittarius. Both objects have been photographed with the ESO 3.6 m telescope, and some preliminary conclusions may be drawn about their nature although further observations are clearly needed for confirmation.

The *Eridanus* object (Fig. 1) lies at position R.A. = $04^h\,22^m.6$; Decl. = −21° 18′ (1950), only 3.5 arcminutes northwest of the 8th-magnitude star SAO 169422. There are reasons to believe that it is an intergalactic globular cluster. Assuming that the brighter, central stars, which are relatively red, are typical globular-cluster red giants of population II, ESO astronomers H.-E. Schuster and R. M. West

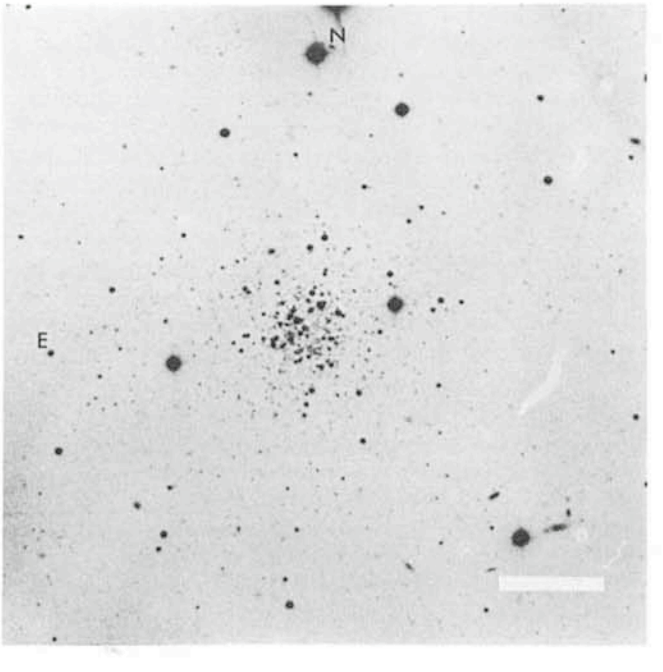


Fig. 1. — *Photo of stellar system in Eridanus obtained with the ESO 3.6 metre telescope in prime focus. Exposure time 90 min on IIIa-J + GG 385. Observer: H.-E. Schuster. The scale is indicated by the 1-arcminute bar.* ▶

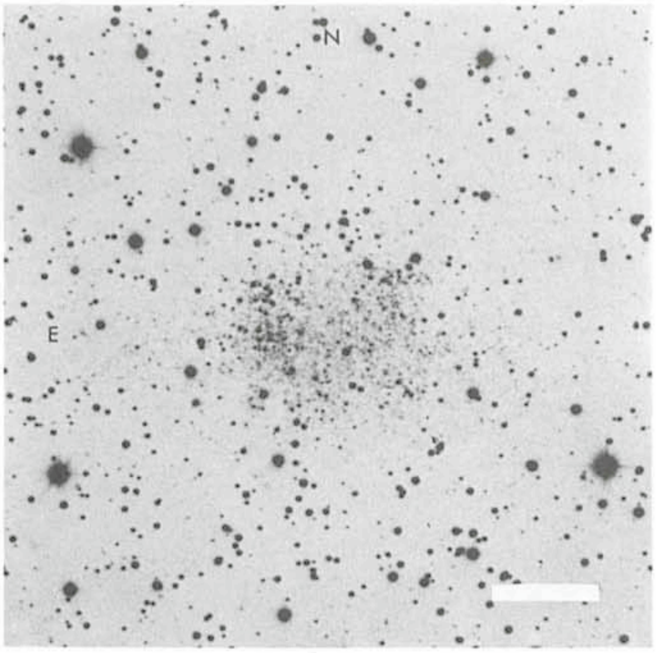


Fig. 2. — *New stellar system in Sagittarius, photographed on July 15, 1977 with the ESO 3.6 metre telescope. 90 min, IIIa-J + GG 385. Observer: S. Laustsen. Same scale as figure 1.*

Tentative Meeting Schedule

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

September 22	Committee of Council, Geneva
November 3/4	Finance Committee, Garching
November 8	Joint meeting of Scientific Policy Committee and Instrumentation Committee
November 24/25	Observing Programmes Committee
December 1/2	Council, Munich

find a distance somewhere between 100 and 250 kiloparsecs (300,000 to 800,000 light-years) and a linear diameter of 30 to 75 parsecs.

On the contrary, the *Sagittarius* object (Fig. 2) at R.A. = $19^h\ 27^m\!.0$; Decl. = $-17°\ 47'$ (1950) resembles the Phoenix and Sculptor objects and is more likely to be yet another, new irregular dwarf galaxy. In that case, it is well outside the Local Group of Galaxies, at a distance of several megaparsecs, and has a diameter of some kiloparsecs.

It is interesting to note that all four objects mentioned here can in fact be seen as weak, patchy "blobs" on the Palomar Sky Survey prints, if you know where to look! Otherwise they can easily be mistaken for plate faults.

Eclipsing Binaries in the Globular Cluster Omega Centauri

Of the many thousand eclipsing binary stars known, fewer than five are members of globular clusters. The powerful methods for determining masses, radii and chemical composition by means of photometric and spectroscopic observations of eclipsing binaries can therefore not be applied to the population II stars in globular clusters. This is really a pity, because improved knowledge about these very old objects would have direct impact on our ideas about the universe (distance scale, earliest epoch, etc.). Hoping to get things moving along this line, two Danish astronomers, Drs. Birger Niss and Henning E. Jørgensen of the Copenhagen University Observatory, have recently started a systematic search for eclipsing binaries in the bright southern globular cluster Omega Centauri. This is their preliminary report, not without hope for the future:

In a recent article (*Messenger,* No. 7—Dec. 1976) one of us discussed the determination of *masses* and *radii* for eclipsing binaries, and from that the *helium abundances.*

For one particular group of astronomical objects, such data are of vital importance for our understanding of their past und present. We are thinking of *globular clusters.* As far as we know today, these are among the oldest objects known, and we believe that their chemical composition resembles the mixture of elements in the very early universe.

According to modern calculations of the formation of elements during the first few minutes of the universe, the abundance of helium should be somewhere between 20 und 30 per cent by weight. Could we therefore determine the amount of helium present in globular clusters, we should have an important cosmological parameter in our hands to check Big-Bang theories.

Stellar Masses in Globular Clusters

With well-determined masses from binaries, we could also establish the absolute mass scale on the cluster sequence. Today, we only know the relative masses of stars in the HR diagrams of the globular clusters from stellar evolution calculations. We believe that horizontal branch stars have masses close to 0.65 $M_\odot$ (solar masses) and that substantial mass loss has occurred in the preceding very luminous red-giant phase. By determining masses of stars at subgiant luminosities we should therefore be able to derive the amount of mass lost. In this field we are also faced with another problem, namely that we cannot find the predicted amount of gas in globular clusters; where has it gone?

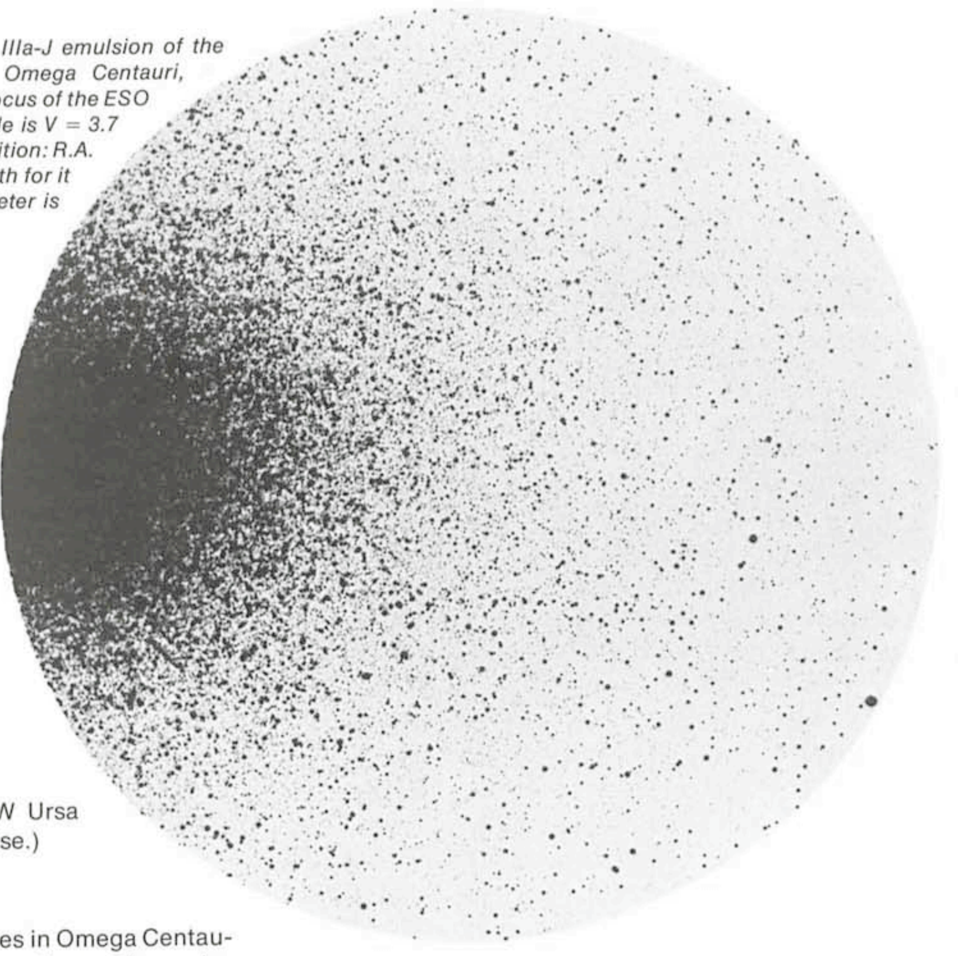
From the radii and temperatures we should be able to make an independent determination of the distance of the clusters. This in turn would give a better value of the absolute magnitudes of RR Lyrae variable stars, which are essential for determining the distance scale of the universe.

Still another property of importance in globular cluster research is the frequency of binary stars. At present we know that five clusters are X-ray sources. It has been suggested that these sources are not of the "classical" binary nature, using among others the argument that the frequency of binaries is low, which is, however, an open question.

From this it should be evident that a thorough search for binaries in globular clusters is of importance in clearing up such problems.

Today only 11 eclipsing binaries are known in the direction of globular clusters, but only three of these are thought to be real members. (One of these three, we believe, is not

A 10-minute exposure on blue-sensitive IIIa-J emulsion of the brightest globular cluster in the sky, Omega Centauri, obtained by Dr. S. Laustsen at the prime focus of the ESO 3.6 m telescope. The integrated magnitude is V = 3.7 and it is visible with the naked eye. The position: R.A. = $13^h 24^m$; Decl. = —47° 13' is too far south for it to be seen from Europe. The linear diameter is about 50 parsecs (160 light-years).



a member, and the other two are W Ursa Majoris systems which are of little use.)

A Search in Omega Centauri

We started to look for eclipsing binaries in Omega Centauri, a bright and large globular cluster on the southern sky. Omega Cen is very massive, and contains approximately three million stars. Furthermore it is a fairly loose cluster, and stars even fainter than RR Lyraes can easily be distinguished in the centre. The distance is only 5 kpc, which makes it one of the closests globular clusters.

The material, i.e. the photographic plates, for this search was obtained by Dr. S. Laustsen with the 3.6 m telescope on La Silla. In January 1977 the primary focus was being tested, so the opportunity was taken to procure 11 plates of the cluster on 5 consecutive nights. The exposure times were 2, 4 and 10 minutes to make a search for variables in the subgiant branch possible. A search for variables in a dense stellar field should be straight forward by blinking the plates. However, before knowing the variables, we decided to investigate if a simple photographic technique could pick out most of the variables for us:

A "sandwich" consisting of a plate put together with a copy on lithfilm of another plate is viewed in a microscope. A lithfilm is a film of extreme contrast, in principle only pure black und pure white is available. In this way the stars on the plate are lit through a perfectly fitted mask, so we see a bright ring around each star.

If, however, a star has changed its magnitude from one plate to the other, the hole in the mask, and therefore the bright ring is either too big or too small. Stars that have varied more than 0.3 magnitude can immediately be seen in the microscope. Using this technique, we found 79 possible variables. Among these are practically all the known variables in the field.

During a pleasant stay at ESO in Geneva, where some of the plates were blinked on the Zeiss comparator, we found 22 more candidates, mostly closer to the plate limit. The simple "sandwich" method proved to be very efficient, as many candidates were only found by that method.

One Probable Eclipsing Binary

We cannot at present establish with certainty how many of the candidates really are new variables. Iris photometry shows that approximately 30 are very probably variables; they are mostly RR Lyrae stars, but half a dozen might be eclipsing binaries.

At least one looks very promising, since this star has dropped 0.7 magnitude on two plates (obtained immediately after each other) when compared to the rest of the plates. It is almost certainly an eclipsing binary, a little more than 1 magnitude fainter (in V) than the RR Lyrae stars, and there are good indications from proper-motion measurements (Woolley, *Roy. Obs. Bull.* No. 2, 1966) that it actually belongs to the cluster.

If it does, there are favourable odds that it is also a spectroscopic binary so that the radial-velocity curve should be measurable. Before definite conclusions can be reached, many more observations must be carried out in order to get a proper light-curve of this and the other candidates, but it looks indeed as if we were one step closer to the determination of the properties mentioned in the beginning of this article.

Binary Frequencies

Finally we should mention that we predict, from the distribution functions of radii, semi-major axes and inclinations, the fraction of binaries that were detected on our plates, and we can therefore give an estimate of the frequency of binaries among the population II stars in Omega Centauri.

The statistics are of course *very* uncertain, but half a dozen eclipsing binaries do *not* support the hypothesis that the Omega Centauri frequency of binaries is much lower than that of population I stars.

Image Processing at ESO

F. Middelburg

Most people have some time seen the results of computer treatment of photographs or TV pictures, for instance of satellite photos. It is amazing how an apparently fuzzy, featureless photo of Phobos suddenly reappears with sharp craters and rifts after having been "washed" in a large computer. The past years have seen an enormous increase in the interest in applying the same image-processing techniques to the images of celestial objects, obtained with ground-based telescopes through the Earth's atmosphere. Significant progress has been made in some places, and we here present what has been done at ESO in this direction. The ESO system is described by Frank Middelburg (ESO/Geneva) who wrote the software and developed the features that are now available. Frank has been with ESO for more than nine years, first in Chile on La Silla, but he came back to Europe three years ago. The Image-Processing System is presently used in combination with the ESO S-3000 measuring machine that performs the scans of the photographic plates, but an important feature of this system is that it is directly applicable to any sort of picture: TV as well as photographic, at the telescope as well as afterwards in the laboratory.

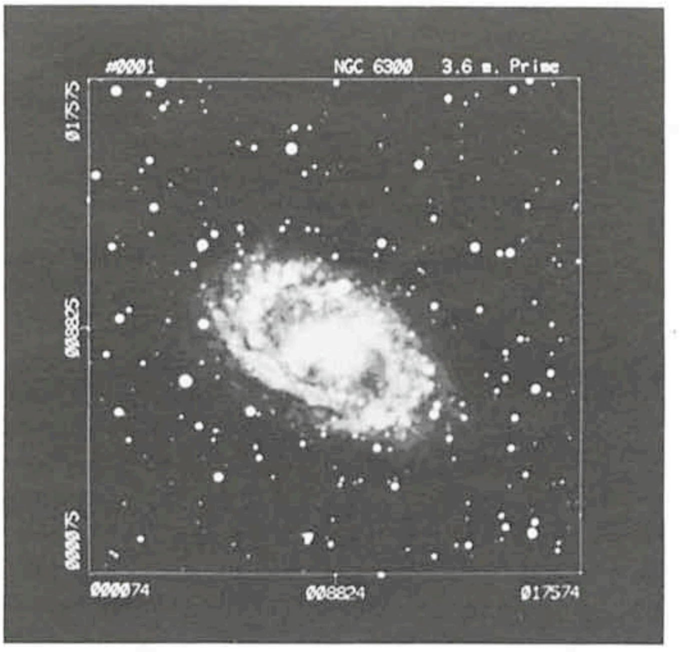


Fig. 1. — *A digitized image. NGC 6300 recorded through photography by S. Laustsen in the prime focus of the 3.6 m telescope. The plate was then digitized by scanning with the Optronics S-3000 microphotometer using a square diaphragm of 100 microns and a sampling step size of 50 microns = .9 arcsec. The brightness scale is plate density which is displayed by 16 levels of quantization. Resolution of the frame is 350 x 350 pixels (picture elements). The frame covers 5.4 arcminutes square. All pictures in this article are digital images which were photographed from the screen of the IMLAC graphic display. Photographic reproduction cannot do justice to the amazing contrast range which the IMLAC is capable of showing.*

When an image is digitized, a sampling process is used to extract from the image values at regularly spaced points. Such a set of samples can be represented for computer-processing purposes as a rectangular array of real numbers. The elements of a digital image or picture are called picture elements or *pixels*.

In astronomy a digitized image may be produced by scanning a *photographic* or an *electronographic* plate with a microphotometer, or the image may be detected and at the same time digitized at the telescope by *television* techniques.

Once an image is digitized, a computer can be used to "improve" the image, such as: better spatial resolution, greater dynamic range or higher signal-to-noise ratio. Then finally the scientific content of the image can be analysed.

As many features in an image can be easily identified by eye yet are difficult to describe algorithmically without ambiguity, an important part of any image-processing computer system is the graphic display device. With such a display and the appropriate software, interactive image processing is feasible. The user seated in front of the graphic display can filter an image, enhance the contrast, etc. while monitoring the results of those manipulations.

The ESO System

In the beginning of 1976, ESO acquired a graphic display device which was duly linked to the in-house computer in Geneva. Soon after that, software development was started. At present an image-processing system is available that will handle many astronomical requirements.

The system consists of an IMLAC graphic display with keyboard, linked to a Hewlett-Packard 21MX host computer with various peripherals attached to it.

The IMLAC has a 21-inch screen of the refreshing type. Besides line drawings, grey scale pictures in sizes of up to 20K pixels can be displayed with 16 levels of quantization. Integral to the IMLAC system is a 24K minicomputer. In our configuration this computer handles the linking with the host computer and does the users I/O via keyboard, cursor or lightpen. However, its main task is the continuous execution of a display programme for generating the picture on the screen. The display programme is dynamically modified by a small resident programme which gets its input via a link from the Hewlett-Packard. This software package, which was designed and written by ESO astronomer S. Lorensen, allows text and graphics to be displayed from the host computer with simple Fortran calls.

The actual processing software executes in a 14K partition of the Hewlett-Packard computer. This machine is not at all dedicated to image processing, the programmes run in a multiprogramming system together with those of other users.

All schemes for further linking to a large out-of-house computer were avoided in order to make an eventual installation in Chile possible.

Images which are selected for processing are read from magnetic tape or disc cartridge to a disc work area. At present this area can hold up to 2×10^6 pixels in both inte-

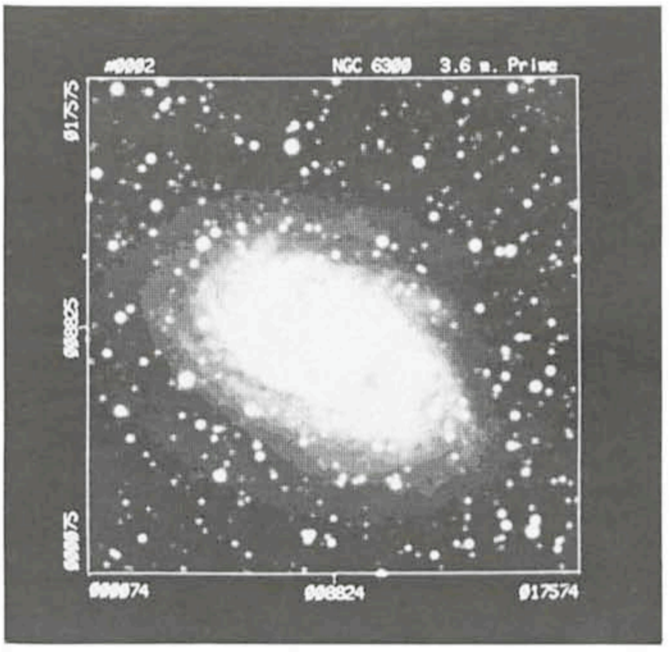


Fig. 2. — *The image of Fig. 1 digitally "squeezed" by a factor of 2, then displayed with a coarser resolution of 175 x 175 pixels. A high threshold was used in an attempt to show the wings of the galaxy (see text).*

ger and floating point format. This on-line storage capability will be doubled in the near future. Completely or partly reduced images may at any time be copied from the work area out again to magnetic tape or disc cartridge. A Calcomp plotter is available for "hard" copies of line drawings as contours and graphs, while for grey scales a polaroid camera can be used.

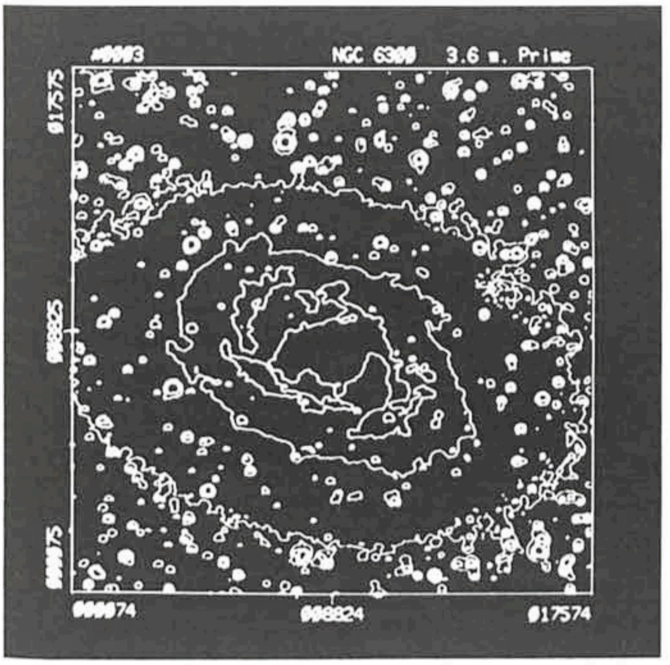


Fig. 3. — *A contour plot with 3 levels. The image shown in Fig. 1 was smoothed with an unweighted window of 3 x 3 pixels. The sample values were also corrected for plate gamma (i.e. the non-linear photographic calibration curve) to achieve a linear brightness scale. Frame size and image resolution are the same as in Fig. 1.*

Software Capabilities

The image processing is controlled interactively by commands with their parameters which are checked for reason and interpreted as they are entered from the keyboard. The command syntax was designed to be understandable by an astronomer or assistant who has a minimal knowledge of computers. Sequences of commands may also be entered into a disc file from where the system can get its control information to run in a batch mode. Commands such as if statements, jumps and loops were developed to allow some programming facilities within batch. Batch is used when the same series of routine commands is often repeated, or to allow the user to do other things while the system processes commands with long execution times. The user can always abort a batch run and take over interactive control.

Up to four images can be shown simultaneously on the screen for comparison. Those images may contain different regions of the same celestial object, the same object observed through different filters or arithmetic operations applied to any of the above. Each image has a fixed size or frame on the screen; however, the user has full control over the scaling and the portion of the image to be displayed within the frame. With scaling an image can be compressed to fit the frame, or a zoom effect can be achieved for a closer look. With large images the frame can be placed on any region desired without loss of resolution as would occur with a compression through scaling.

A cursor can be used to point to features of interest. The system can pick up the position of the cursor and will respond with the exact location and brightness of the feature.

Image Transformations

There are several ways of displaying an image, each having its use. The most straightforward, and usually the most revealing, is a grey scale display. Grey scales are very suitable for showing the results of linear and non-linear contrast manipulations. As the information contents of an image is often larger than the mind can register in a single glance, the computer can enhance an image to show only some of the information that it contains. Contrast can be improved by stretching out the digitized levels of an interesting part of the data to cover the quantization range. The regions falling outside the range are then simply ignored. This technique, which has the advantage that the image remains linear, is useful to determine how far the wings of a galaxy extend into the sky background. Other methods of showing an image are by contours (Fig. 3), multiple line scans (Fig. 4) and bilevel pictures. Multiple scans with "hidden" lines are suitable for images with sharp brightness transitions as stars, they give less information when the shading varies slowly. Bilevel pictures consist of only two grey levels, the separation given by a single threshold. As they are very efficient in display computer memory, they can have a big frame. A large amount of qualitative information on an image can be obtained with a "histogram", which is a plot of the number of times each grey level occurred in the image as a function of the grey level. Displaying a histogram is usually the first step in processing a new image as it is a quick way to estimate exposure and contrast.

Noise Removal

Often an image must have its noise removed by smoothing or filtering. The basic difficulty with noise removal techniques is that, if applied indiscriminately, they tend to blur

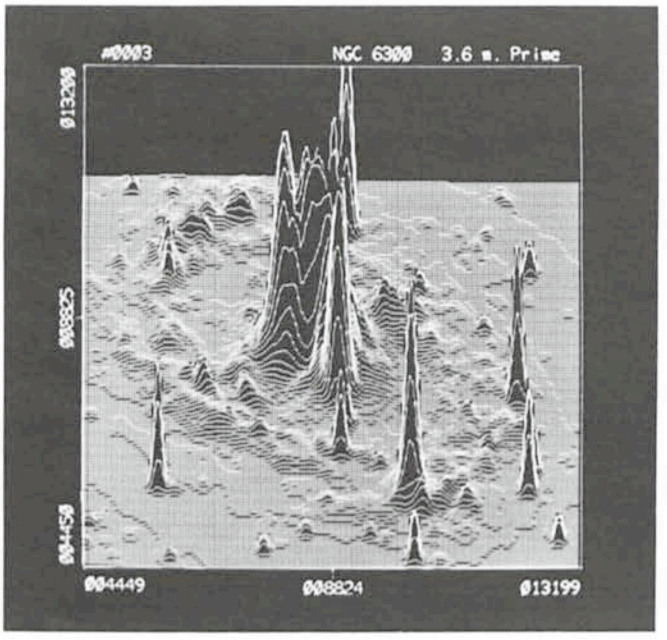


Fig. 4. — *Multiple line scan. The central region of Fig. 3 scaled up by 2. Here also the brightness scale is linear.*

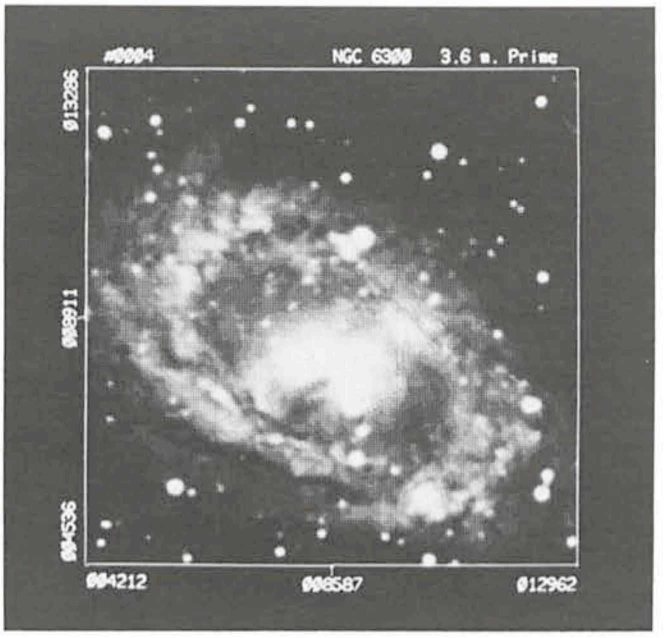


Fig. 5. — *Central region of the same plate now scanned with a diaphragm of 60 microns and a step of 30 microns = .6 arcsecond. The image was digitally squeezed by a factor of 2 and then displayed with 175 x 175 pixels. The reason for this squeezing is that it is not always possible to hold a picture with the highest resolution in the display processors memory. Brightness is plate density.*

the image. The system offers several methods to achieve a "smoother" image. For example, where a data point is represented by more than one pixel, weighted window averaging could be used. A square window of specified size is placed around each pixel, and a weighted average intensity of all pixels in the window is used as the new value of the central pixel. Gaussian weighting factors are normally used. The resulting image allows the eye to see a more continuous distribution of intensities.

At a certain stage a quantitative restauration may have to be made of the image to convert it from an instrumental system to an astronomical meaningful system of photons per pixel. All imaging systems as photography and TV devices degrade the image in some manner or other. For photographic plates routines were developed for the non-linear transformation of densities to intensities. TV-type sensors show the problem of non-uniform photometric response. However, if an image that is made by the same sensor of a uniform field (called an exposure mapping) is available, then the restauration is straightforward. Each pixel of the original data is divided by the corresponding pixel of the mapping, which achieves the effect of a uniform image.

Image Arithmetics

A powerful facility of the system is the capacity to perform calculations based on images. These calculations can include various arithmetic operations as adding, subtracting, multiplying or dividing. In fact, a command is available that can do many calculations on several images in a single pass. Thus images can be combined to construct other images with astronomical meaning. For example, after alignment, the difference of two images could be used to map the B-V colour structure of galaxies.

Other routines available in the ESO image-processing system worth mentioning are: removal of unwanted details in an image by polynomial interpolation over the surrounding area, image rotation and shifting, area integration for determining the flux of stars or extended object, and many utility routines as listing, dumping, logging and directory listings.

All the images described above were tacitly assumed to be two-dimensional. However, single-dimensional images as produced by scans of spectra can very well also be handled by this system. Most of the routines, e.g. filtering and non-linear calibration, work with both single and two-dimensional data. Various modules were added to handle spectral data only as transformations to a linear wavelength scale, line area integration and interactive continuum determination.

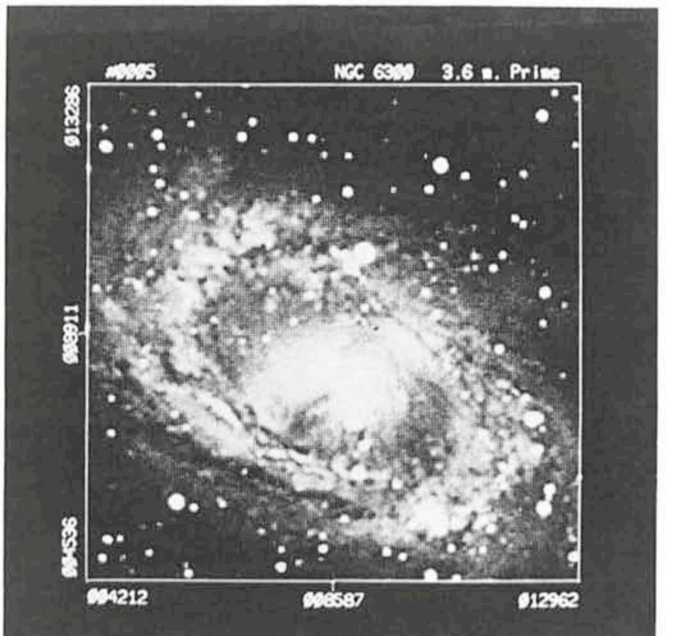


Fig. 6.—*A laplacian sharpening filter applied to the image of Fig. 5. The high spatial frequencies were boosted leaving the low ones relatively unaffected. Note the increase in fine detail.*

Real-time Reduction

As the I/O with the graphic display is routed through a single module, the system can be easily modified to work with other than an IMLAC display. In fact, it is planned to use parts of the image-processing system at the telescope with a Tektronix display for the real-time reduction of data produced by an image dissector scanner.

In its present state the system consists of 97 commands with varying levels of computer sophistication. However, further development has not stopped. New routines are being regularly added with the aim of providing more reduction facilities in those areas of astronomy where imagery is the basic data format.

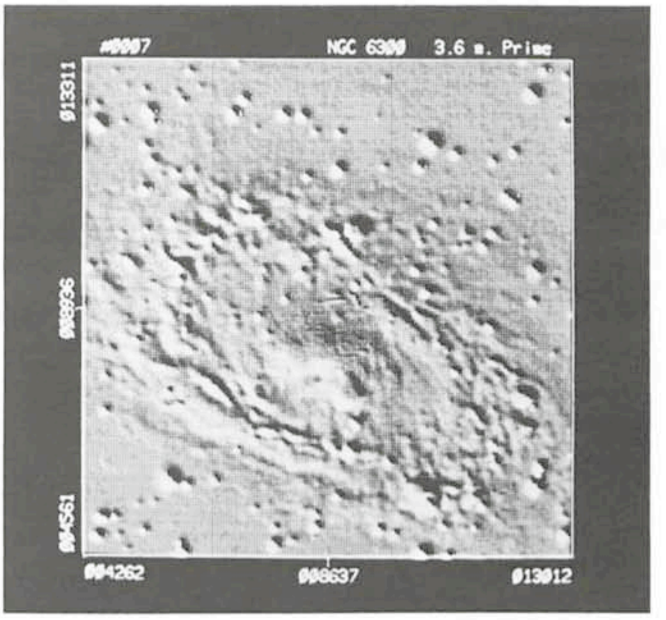


Fig. 7. — *Subtracting a slightly misaligned image from itself produces this. The lower and the higher grey levels show where the slope is the steepest.* ▶

The Large-Field Camera for the 3.6 m Telescope

One of the important features of the ESO 3.6 m telescope is that the optics permit a comparatively large field (about 1°) to be imaged on a photographic plate in the prime focus. This is possible due to the chosen shape of the primary mirror (modified Ritchey-Chrétien) and a triplet corrector in front of the photographic plate. The large-field camera is now ready for shipment to La Silla. It incorporates some unusual features that are not seen at other telescopes and was designed by ESO engineer Sten Milner in Geneva. He gives this information to the future users:

The large-field camera (Fig. 1) was received from the manufacturer in July 1977 and is now undergoing thorough testing at ESO, Geneva, before being shipped to La Silla, at the end of the year. It can be mounted in the Cassegrain focus, but will mainly be used in prime focus as soon as this focus gets equipped with the triplet adapter in mid-1978.

The camera consists of a manually *"quick-connect"* plate holder, a remotely-controlled shutter and a filter box with four filters, either colour or interference filters. The fil-

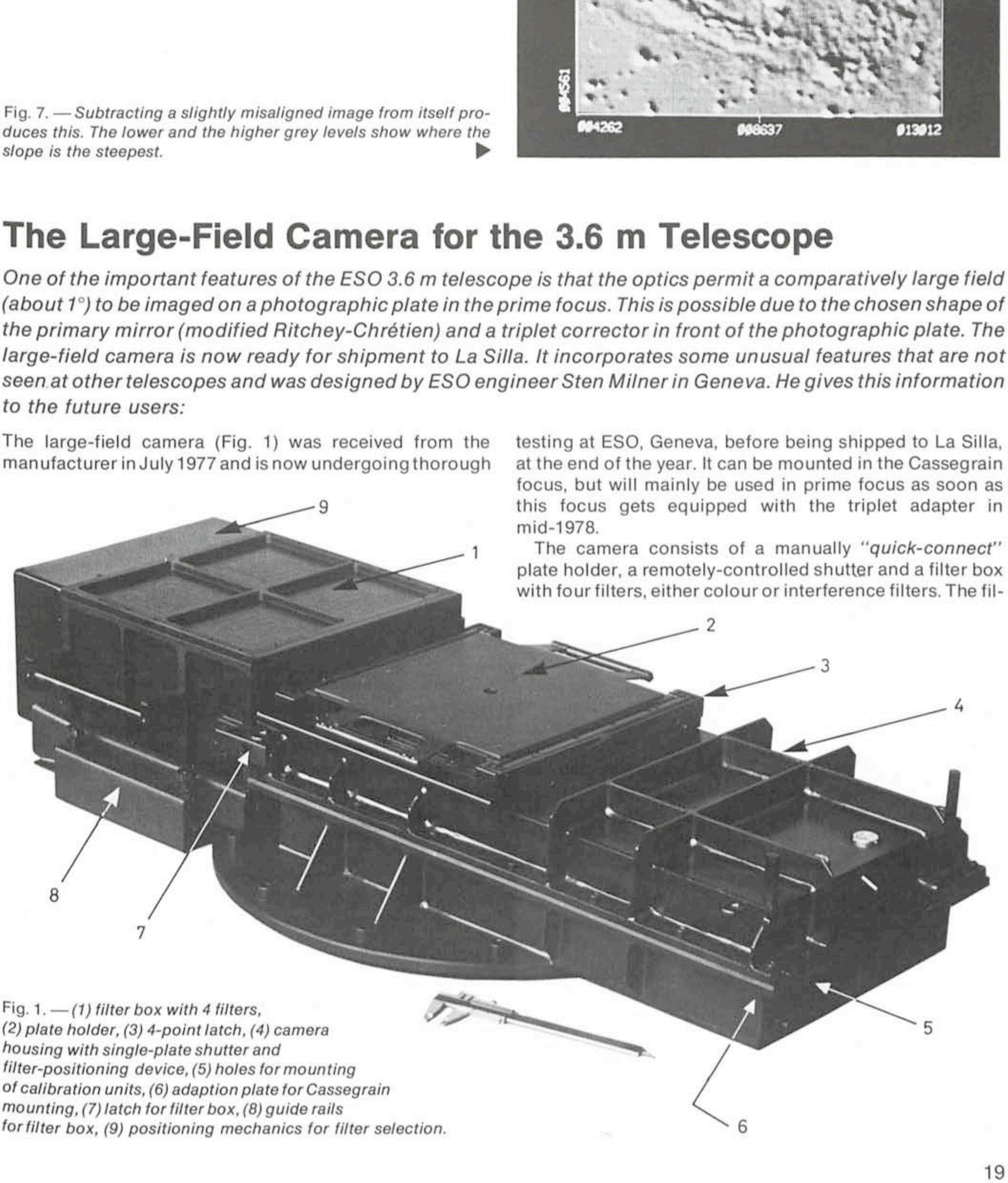


Fig. 1. — *(1) filter box with 4 filters, (2) plate holder, (3) 4-point latch, (4) camera housing with single-plate shutter and filter-positioning device, (5) holes for mounting of calibration units, (6) adaption plate for Cassegrain mounting, (7) latch for filter box, (8) guide rails for filter box, (9) positioning mechanics for filter selection.*

ters can be remotely selected and positioned in front of the photographic plate. It has a maximum useful aperture of 220 x 220 mm. The plates have the dimensions: 240 x 240 x 2.3 mm, and the colour filters 230 x 230 x 2 mm or 230 x 230 x 10 mm if interference filters are used.

In addition to this unit will be constructed a *remotely-controlled* plate-changer containing up to eight photographic plates of 240 x 240 x 1 mm, or film sheets of 240 x 240 x 0.2 mm, which replaces the single-plate holder. The plate or film sheet is held to the back-up plate by a low vaccum. The introduction of the plate changer reduces the dead time and manipulation effort on the telescope, since the time to change a plate and filter will be only 20 sec, and this can be made in any telescope position. The eight plates are contained in a light-weight cassette which is connected easily to the general plate-changer housing when the telescope is in its horizontal position. The plates can be marked by an 8-digit alphanumeric LED unit, placed in the plate changer. This plate changer is actually in its final design stage and will be available in mid-1978.

A Dark Cloud in the Centre of Elliptical Galaxy NGC 3311

Professor Per Olof Lindblad spent the first half of 1977 with the ESO Scientific Group in Geneva. During this time he and Dr. M. Disney initiated a study of the structure of galaxies and together with Dr. S. Laustsen high-resolution photographic plates were obtained with the 3.6 m telescope. In this note Professor Lindblad discusses one of the galaxies and its companions.

The cluster of galaxies Abell 1060 is a fairly rich group of comparatively bright galaxies in the Hydra constellation at $\alpha = 10^h\,34^m$ and $\delta = -27^\circ\,16'$. Close to the centre of the cluster we find two 12th-magnitude elliptical galaxies, NGC 3309 and 3311, separated by about 1.'6, 3311 lying to the east of 3309.

The average radial velocity of the cluster is 3233 km/s relative to our local group of galaxies. Assuming a Hubble constant of 55 km s^{-1} Mpc^{-1}, we may thus derive a distance of 59 Mpc. This gives an apparent separation of the two elliptical galaxies of 27 kpc. The real separation in space may of course be larger, if they are not at exactly the same distance. The velocity difference between the two galaxies amounts to about 300 km/s.

According to photoelectric measurements by S. van den Bergh (*Astrophys. Journ.* **212,** 317, 1977) and by M. Disney,

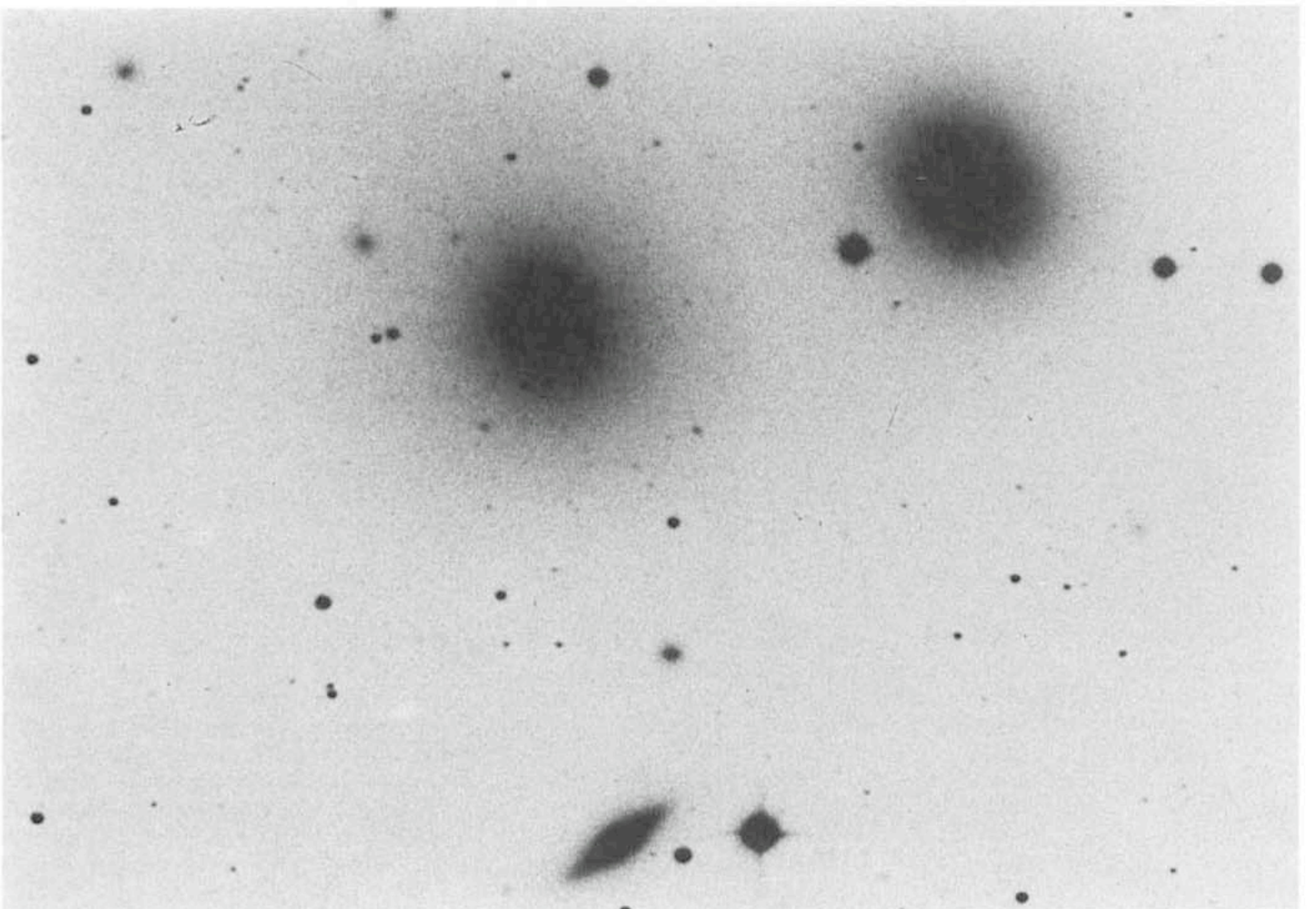


Fig. 1. — *The centre of Abell 1060 cluster of galaxies. To the upper right elliptical galaxy NGC 3309 and in the centre NGC 3311. The scale is given by the distance between the centres of NGC 3309 and 3311 which is about 100 arcseconds. The diffuse objects surrounding 3311 are globular clusters (see text). ESO 3.6 m telescope, 90 min. IIIa-J + GG 385.*

who spent some months of 1977 with ESO in Geneva, the brightness distribution is quite different in these two galaxies. This was the reason why a series of photographs centred on the group was taken by Svend Laustsen with the 3.6 m telescope in May 1977.

Figure 1 shows a reproduction of a 90-minute exposure in the prime focus on a baked IIIa-J plate with a GG 385 filter which covers the centre of the cluster. The different character of the two ellipticals may be seen already on this plate. Figure 2 is a 15-minute exposure with the same plate-filter combination. There, we surprisingly found a very marked absorption lane (dark cloud) at the very centre of NGC 3311. A close inspection shows a small bright spot just outside the eastern edge of the dark cloud. Also one may suspect an extremely narrow luminous bridge crossing the absorption lane from south-east to north-west, although this should be confirmed on other short exposures in very good seeing.

Malcolm Smith and Daniel Weedman (*Astrophys. Journ.* **205,** 709, 1976) using the 4 m telescope at Cerro Tololo discovered a large number of globular clusters surrounding NGC 3311 appearing at a magnitude of B ≈ 23.5–24. This halo of globular clusters is well seen in Figure 1, thus indicating the limiting magnitude of this 3.6 m plate.

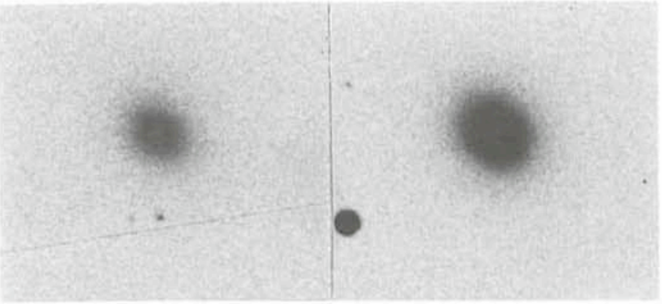
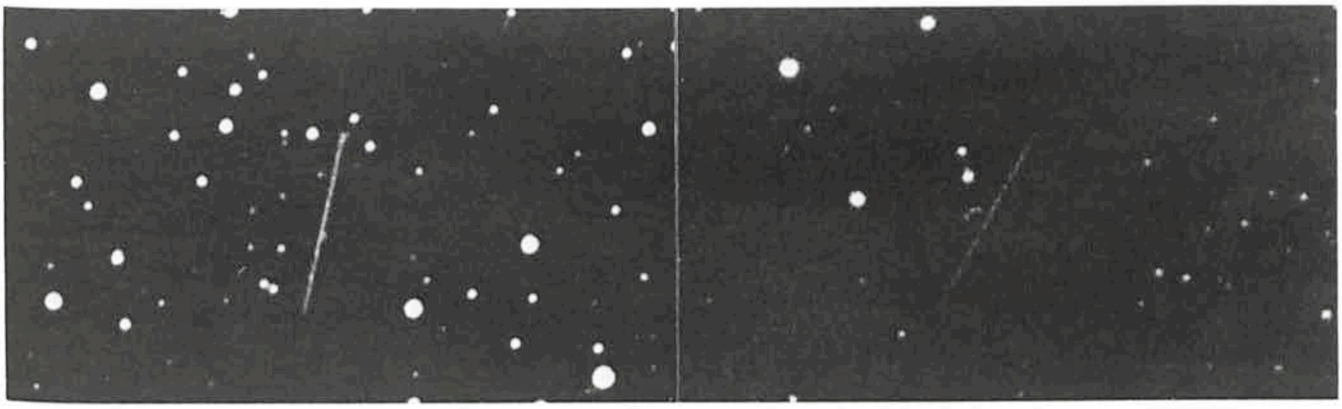


Fig. 2. — *The centres of NGC 3311 (left) and NGC 3309. The small dark cloud in 3311 is readily seen. 15-min exposure on IIIa-J + GG 385, ESO 3.6 m telescope.*

The cluster Abell 1060 is a relatively weak X-ray source with a large error box and with a luminosity of $1.5 \cdot 10^{43}$ ergs/s which is similar to that of the Virgo cluster.

The cluster is also a radio source. While the original Ohio position is more than half a degree off the cluster, M. Disney and J. Wall (1977, *Monthly Notices Roy. Astron. Soc.* **179,** 235) have now derived a new position with the Parkes telescope. The source is situated in the immediate neighbourhood of the two elliptical galaxies .

Latest Asteroid Discoveries at ESO



Two new minor planets were discovered with the ESO Schmidt telescope in April-May 1977. The photos show the discovery trails. To the left is that of MP 1977 HD which was seen on a 90-min red plate, obtained on April 27. It is remarkable because of its southern declination: it reached −67° in June. MP 1977 JA (to the right) was discovered on May 15. Both have very unusual orbits; 1977 HD belongs to the very rare Pallas *type (high inclination, semi-major axis 2.7 Astronomical Units) and 1977 JA is of* Phocaea *type (high inclination, semi-major axis 2.3 A.U.). Discoverer of both was ESO astronomer H.-E. Schuster.*

Design of the Coudé Auxiliary Telescope (CAT)

A unique feature of the ESO 3.6 m telescope is the Coudé Auxiliary Telescope that will feed the large coudé spectrograph. The design of the CAT is now virtually finished and ESO engineer Torben Andersen from Geneva reports:

Coudé Auxiliary Telescope

The ESO 3.6 m telescope will be equipped with a coudé spectrograph. Whenever the telescope is used in Cassegrain or prime focus, it would not be possible to use the coudé spectrograph unless another means of collecting star light were available. To provide a second light source for the spectrograph, a coudé auxiliary telescope (CAT) will be built and installed close to the 3.6 m telescope.

A model of the CAT is shown on Fig. 1. The telescope will be placed in a 24 m high tower (Fig. 2) which is already erected close to the 3.6 m building. The CAT will have an alt-alt mounting. This permits the exit light beam (passing through the hollow shaft of the south bearing) to remain on a fixed axis during its passage to the coudé spectrograph of the 3.6 m telescope. The light will pass from the CAT tower to the 3.6 m building within a steel tube, thereby preventing air turbulence between the buildings from deteriorating the optical quality.

Configuration

The CAT is primarily intended for spectroscopic use. Although a photometer could eventually be mounted on the centre section (in a Nasmyth mounting), it is unlikely that this will happen during the first years of operation.

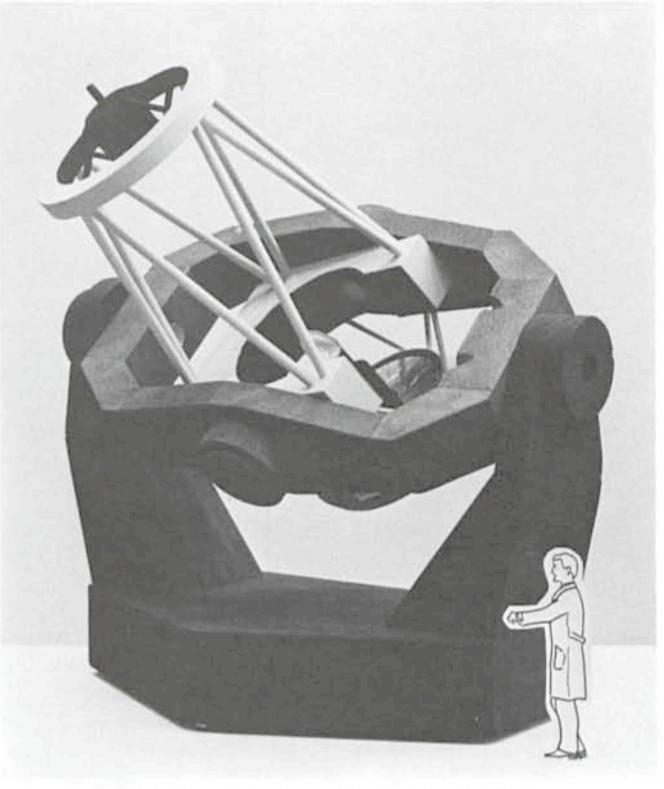


Fig. 1. — *Model photo of the coudé auxiliary telescope.*

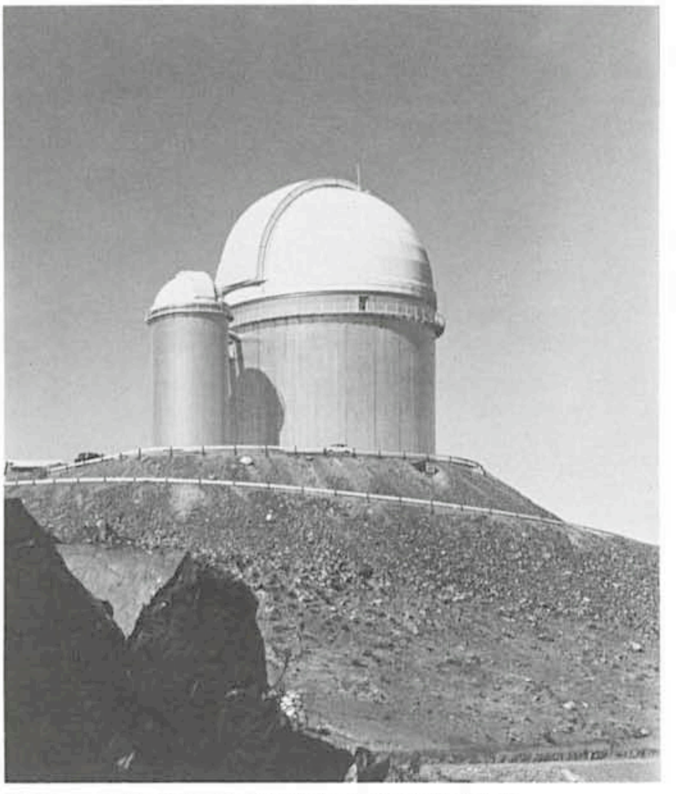


Fig. 2. — *3.6 m telescope building with CAT tower.*

The CAT will be equipped with a total of six mirrors. The primary will have a diameter of 1.47 m and a thickness of 19 cm. There will be four secondaries mounted on a turret. These mirrors will all have the same geometry, however three of them will be dielectrically coated (for different colours), and one will be integral. The observer may choose the mirror that suits his application best by remote control. Mirror 3, which is flat, will receive a normal aluminization. During observation, this mirror will turn slowly with respect to the tube to keep the outgoing light-beam fixed in space. The mirror rotation will be performed with a high-precision servomechanism.

The optical layout of the telescope follows the Dall-Kirkham principle with an ellipsoidal primary and spherical secondaries. The telescope will have an f-ratio of f/120. In future the telescope may be used at this f-ratio, but its immediate use will be with a focal reducer converting to f/32 (as for the 3.6 m telescope). The field of the CAT will be approximately 2 arcminutes.

The CAT will have an alt-alt mounting, the principle of which is clearly seen on Fig. 1. None of the telescope axes will be parallel to the rotational axis of the earth. This will normally require that both axes move during tracking, a feature easily obtained by computer control. The alt-alt mounting leads to a field rotation, which, in most cases, is not important for spectroscopy at the coudé focus.

The telescope tube will have a normal Serrurier structure to support the primary and the secondaries. The flat Nasmyth mirror will be supported by a pedestal which is fixed on the main mirror cell through the central hole of the primary. A counterweight will be added on the lower side of the main mirror cell to counterbalance the weight of the Nasmyth mirror and the pedestal. The counterweight will be attached to the pedestal in such a way that it tends to cancel out angular deflection of the pedestal, leading to a rotation of the Nasmyth mirror.

The tube will be supported by a cradle-formed welded structure via axially preloaded radial groove ball bearings. On one side of the cradle the drive will be mounted, on the other side a safety brake. The drive will be composed of a large Inland torque motor with a peak torque of 414 kpm, an Inland tachogenerator with a sensitivity of 514 V/rad/sec and an Inductosyn incremental encoder with an increment of 0.06 arcsec. All of these components will be coupled directly to the tube-shaft ("δ" axis) without any sort of gearing. Such a configuration is very attractive, since it leads to a stiff and fast servo.

The safety brake on the other side of the cradle will be spring-loaded. In the event of a power failure this brake will prevent the telescope tube from turning in an uncontrolled manner due to unbalance or wind forces.

The rotational axis of the cradle will be almost horizontal and will coincide with the axis of the light-beam path to the spectrograph. Rotation will be carried out with a drive and a safety brake of the same kind as that used for the δ axis. Here also, radial groove ball bearings will be used.

The pedestal supporting the cradle and the tube will be supported on three adjustable feet.

The CAT will be equipped with a computer-control system, which will resemble that of the 3.6 m telescope. It is intended to place the main control panel for remote control of the CAT in the coudé room of the 3.6 m. The computer will continuously control four servomechanisms: two main drives, the Nasmyth mirror drive and the focusing drive. Since the first three require continuous coordination, manual control will not be possible.

The main servos will comprise current-, acceleration-, velocity and position-loops. Finally a guiding loop may be added as required.

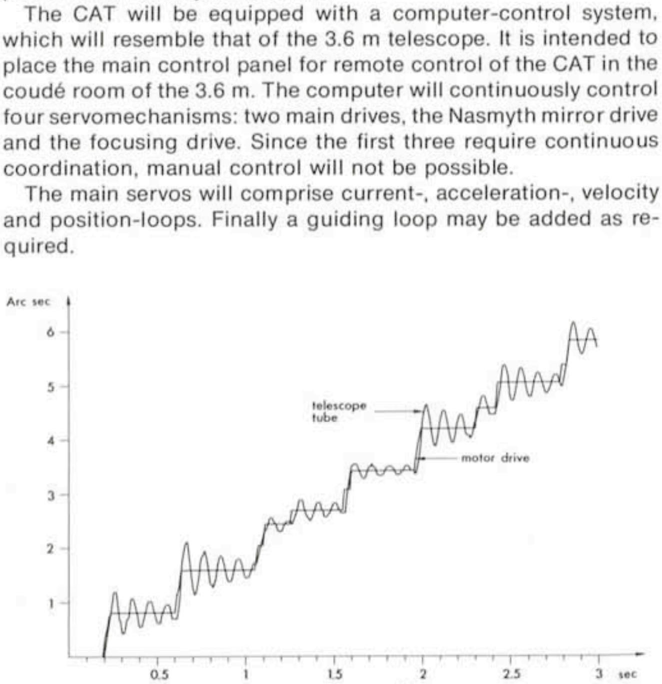


Fig. 3. — *Simulation curve showing how the servo system behaves during tracking if the bearing friction is too high.*

Design Techniques

The CAT will be a telescope of a new generation. It will have a non-traditional mounting and will use direct-drive motors. The design process of this telescope has been facilitated by the fact that modern and effective calculation methods are finding more use and are becoming generally available. In the following a few of the calculations performed during the design will be described.

During tracking the main servos drive the telescope tube about two axes simultaneously. During this activity the velocity of each axis may vary in the range 0-25 arcsec/sec. It is thus sometimes required to run a drive very slowly; the servos must therefore have good slow-running characteristics. To ensure that the selected components (motor, tachogenerator, encoder, etc.) will perform adequately well, some servo calculations were carried out.

A *linear* calculation has given information on the necessary loop gains and on the spectral noise sensitivities of the system. A *non-linear* simulation of the servodrives, using the "Continuous System Modelling Program" from IBM, has given information on transient responses of the drives and on the sensitivity to non-linear effects such as friction.

An example of a curve from such a simulation is seen on Fig. 3. This shows what happens during slow tracking and in the hypothetical case that the bearing friction is far too high. A stick-slip effect would occur and the drive would move in jerks. As a result of this effect and the resilience in the mechanical link between the tube and the drive, an oscillation in the tube position would occur. This curve alone does not give sufficient design information; however, together with a number of similar curves a reasonable evaluation of the proposed servo system is possible.

Experience shows that gravity deflections in a well-designed telescope do not tend to originate from deflection of one single element of the mechanical structure. The displacements of the optical elements normally occur as the result of a large number of minor deflections at different places in the telescope. Therefore, simple calculations, based on models with only a few beams, tend to become too optimistic. This is especially so when the eigenfrequencies of the telescope are computed.

A realistic calculation of the gravity deflections is desirable since it serves as a basis for the design of the structural members of the mechanical construction. A computer analysis of the CAT, to predict gravity deflections and resonant frequencies, has therefore been carried out with a finite element programme called EASE. This programme has calculated deflections and forces in an imaginary structure looking very much like the CAT, but only consisting of beams. Fig. 4 shows the beam approximation model of the telescope. The computer programme has furthermore predicted that the lowest resonant frequency will be around 10 Hz.

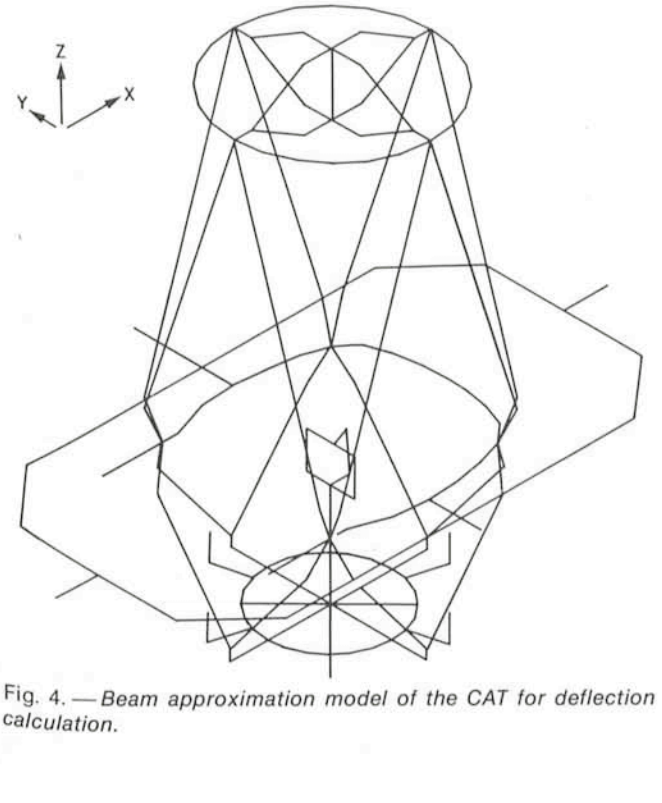


Fig. 4. — *Beam approximation model of the CAT for deflection calculation.*

Due to the use of this optimization technique (and to the use of an alt-alt mounting) the CAT will only weigh 16 tons. This is less than half of the normal weight of a 1.5 m telescope.

The configurations of the mirror cells of the primary and the flat Nasmyth mirror have been calculated by Dr. G. Schwesinger, who is acting as a consultant for ESO on the CAT project. Dr. Schwesinger has calculated that a main mirror cell with 12 axial supports situated on one ring can be used. Nine of these are of the astatic lever-arm type and three are fixed. The radial support system consists of 8 push-pull astatic lever arms carrying the entire load and three temperature-compensated fixed supports carrying no load.

The Nasmyth mirror cell will have 7 axial supports and 1 lateral support in a central hole.

Time Schedule

The mechanics of the CAT are now completely designed and manufacture will start this autumn. This is also the case with the optical elements. The electronic hardware is currently being designed and the parts will soon be manufactured or ordered.

It is planned to perform a test assembly in Geneva in one year from now, i.e. fall 1978. The telescope will go into regular operation in Chile about one year later, around January 1980.

All of ESO/La Silla

ESO photographer Bernard Pillet obtained this aerial photo of La Silla from the "Navajo" plane that ensures the Santiago-Pelícano connection. In the lower left are the bodega and the garage, the "New Pelícano" and the clubhouse. Higher up the mountain is the new astronomy building and the hotel together with the "dormitories". The telescopes on the long, flat ridge are from below: the ESO 50 cm, the Danish 50 cm, the Bochum 61 cm, the 1.52 m, the 1 m, the GPO and the Danish 1.5 m. The Schmidt dome is seen in front of the "old camp" (now removed), next to the new Astro-workshop. Near the watertanks on the lower summit stands the Swiss 40 cm telescope and finally, at the La Silla summit, 2,400 metres above sea level, the 3.6 m telescope with the CAT tower.

After all that talk about the ESO CAT (p. 21) the reader may well need assurance that the ESO dogs are still going strong. The undisputed canine ruler of La Silla, SONIA, poses proudly for a portrait in her tenth year on the mountain. We regret that her principal subject, German shepherd LORD, untimely and in great haste abandoned the studio when certain noises from the nearby ESO kitchen announced the approaching dinner hour.

SONIA, la indiscutible reina entre los caninos en La Silla, posa orgullosa para el fotógrafo con ocasión de su décimo año en el cerro. Lamentamos que su compañero de juego más importante, el pastor alemán LORD, haya abandonado el estudio prematuramente y con gran apuro, cuando ciertos ruidos desde la cercana cocina anunciaban la próxima hora de comida.

ALGUNOS RESUMENES

1962 hasta 1977—15 años ESO

El día 5 de octubre de 1977 la ESO festeja su décimoquinto año de existencia. Con la firma de la Convención de ESO por los representantes de cinco países europeos, nació la ESO el día 5 de octubre de 1962. Fue ratificada un año más tarde, y en el año 1964 se eligió La Silla como lugar para el observatorio. Las observaciones astronómicas comenzaron en el año 1968 con el telescopio fotométrico de 1 m, al cual le han seguido hasta ahora ocho telescopios. más.

El nacimiento de la ESO fue de gran importancia para la astronomía europea, y también en el futuro la organización jugará un papel importante en la astronomía, cuya influencia pasará mucho más allá de los límites de sus países miembros.

El telescopio de 3,6 m de excelente calidad óptica

Para comprobar la calidad óptica del telescopio de 3,6 m, el grupo óptico de ESO ha examinado detalladamente los focos primario y Cassegrain. Como indicado por el Dr. Wilson, jefe del grupo óptico, se encuentran a disposición los resultados preliminares de estas pruebas. Ellos muestran claramente que la óptica del telescopio es casi perfecta, y las esperanzas puestas en el telescopio más grande de la ESO no sólo se han cumplido totalmente, sino que hayan sido probablemente superadas en gran escala.

Los primeros astrónomos visitantes para el telescopio de 3,6 m

Por primera vez el telescopio de 3,6 m es puesto a disposición de los astrónomos visitantes. La demanda fue tan grande que sólo casi la mitad de los programas propuestos pudieron ser aceptados. Fue especialmente satisfactorio el gran interés por la investigación extra-galáctica, la cual hasta ahora había sido solamente posible en forma restringida debido a la falta de telescopios grandes en Europa.

Se descubren dos nuevos sistemas estelares

Durante la evaluación de las placas del telescopio Schmidt para el «ESO (B) Survey» se descubrieron dos sistemas estelares hasta ahora desconocidos. Se encuentran en las constelaciones de Eridanus y Sagittarius. Ambos objetos fueron luego fotografiados con el telescopio de 3,6 m.

El objeto en la constelación de Eridanus (ver pág. 13, fig. 1) podría ser un cúmulo estelar en forma global cuya distancia fue estimada en 300000 hasta 800000 años luz por los astrónomos H.-E. Schuster y R. M. West.

El sistema estelar en la constelación Sagittarius (ver pág. 14, fig. 2) es probablemente una galaxia enana irregular a millones de años luz de distancia.

Para aclarar definitivamente la naturaleza de estos objetos se necesitarán sin embargo más observaciones.

LATEST NEWS

Ariel 5 Confirms LMC X-4 Optical Identification!

Things move fast in astronomy these days. In the last issue of the *Messenger*, Drs. Chevalier and Ilovaisky reported the probable optical identification of the LMC X-4 X-ray source. They found a 1.408-day period in the light-curve of their candidate star. Now, Drs. N. E. White and P. J. Davison of the Mullard Space Science Center report in IAU Circular 3095 (August 18, 1977) that: "Ariel 5 observations during July 15–23 reveal LMC X-4 to eclipse for 0.206 ± 0.008 day every 1.413 ± 0.007 days; mideclipse occurred on July 18.114 ± 0.004 UT. The coincidence of the X-ray period and phase with the optical values (.....) confirms the identification."

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 1979 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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