THE MESSENGER

EL MENSAJERO

No. 60 – June 1990

Planning the VLT Interferometer

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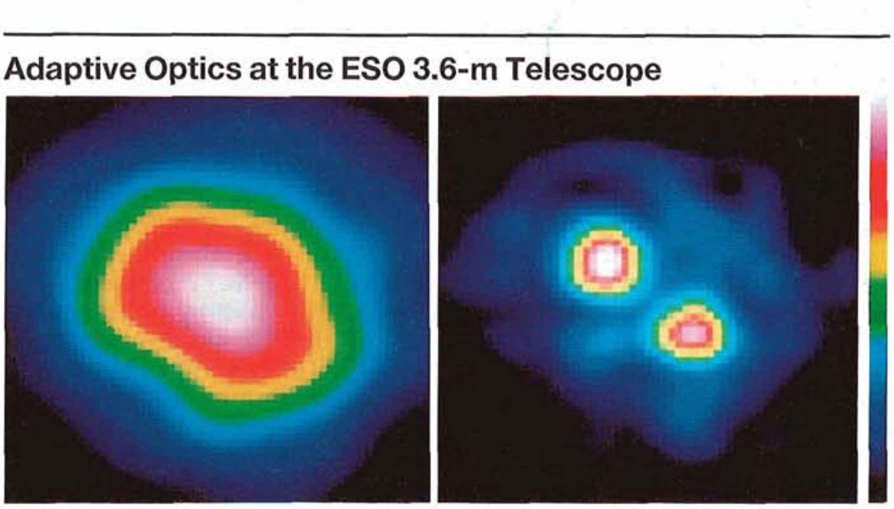
1. The VLT Interferometer: One of the Operating Modes of the VLT

1.1 Its Context

The Very Large Telescope has three different modes of being used. As four separate 8-metre telescopes it provides the capability of carrying out in parallel four different observing programmes, each with a sensitivity which matches that of the other most powerful ground-based telescopes available. In the second mode the light of the four telescopes is combined in a single image making it in sensitivity the most powerful telescope on earth, almost 16 metres in diameter if the light losses in the beam combination can be kept low. In the third mode the light of the four telescopes is combined coherently, allowing interferometric observations with the unparalleled sensitivity resulting from the 8-metre apertures. In this mode the angular resolution is determined by the distance between the telescopes (up to 120 metres), rather than by the resolution determined by the individual telescopes (set by the atmospheric seeing, or by the diffraction limit of single 8-metre apertures while using adaptive optics or speckle interferometry). Following an in-depth study by the VLT Interferometry Working Group under the chairmanship of P. Léna (published in VLT Reports 44 and 49), the interferometric mode of the VLT was included in the VLT proposal, and accepted in the approved VLT implementation. P. Léna described the concept and planning for the interferometric mode of the VLT at

Adaptive Optics at the ESO 3.6-m Telescope



This false-colour photo illustrates the dramatic improvement in image sharpness which is obtained with adaptive optics at the ESO 3.6-m telescope. See also the article on page 9.
It shows the 5.5 magnitude star HR 6658 in the galactic cluster Messier 7 (NGC 6475), as observed in the infrared L-band (wavelength 3.5 μm), without ("uncorrected", left) and with "corrected", right) the "VLT adaptive optics prototype" switched on. The diameter of the uncorrected image is about 0.8 arcseconds, corresponding to the instantaneous "seeing" disk. When corrected, the image sharpness increases nearly fourfold; the diameter is now only 0.22 arcsec. This corresponds to the diffraction limit at this wavelength; the diffraction rings are well visible. The improved sharpness reveals that the star is double; the angular distance between the two components is 0.38 arcseconds.
Although it is not evident on this picture in which the intensity scales have been normalized to the same level, the central intensity of the corrected image is much higher than that of the uncorrected. By concentrating the light better, the efficiency of the telescope is correspondingly increased. This means that shorter exposure times are possible or that fainter objects can be observed than before.

that time in an earlier article in the *Messenger* (P. Léna, *The Messenger* **53,** 53, 1987).

Since the acceptance of the VLT proposal, the VLT final definition and design, including the final site testing which will soon lead to the VLT site choice, has been rapidly proceeding. The implementation planning of the interferometric mode is an essential part of that. Interferometry places its own requirements on the design and location of the 8-metre telescopes, on the site choice and development, and in the definition of the observatory infrastructure. In addition to the 8-metre telescopes, the VLT includes two smaller movable 2-metre-class telescopes (the so-called auxiliary telescopes), whose design and configuration has to proceed in parallel with the others. To aid in this planning a VLT Interferometry Panel was formed, whose members represented the expertise in interferometry in the ESO member countries[1]. This report summarizes the implementation plan of the panel for the so-called *VLT Interferometer* (or VLTI) as proposed to ESO. This plan is out of necessity incomplete since the site for the VLT remains to be chosen.

1.2 Philosophy Followed in the Implementation Plan

Right from the beginning the panel took as the basis for its studies the desire to make use of the unique opportunity provided by the presence on one site of four identical, state-of-the-art 8-metre telescopes to do interferometric imaging. Its definition of the VLTI is thus in the first instance based on the coherent combination of the large telescopes. The sub-array of auxiliary telescopes is truly auxiliary to this goal. It serves two main functions. First, it complements the main-array of 8-metre telescopes to give more interferometric baselines. Second, it provides for an interferometric capability by itself which is available 100 % of the time. This function is of use not only when the full power of the 8-metre telescopes is not needed for the observations being carried out, but also during the important initial phases of the VLTI, for the commissioning and debugging of the interferometer. The latter resulted in the desire to incorporate the VLTI sub-array into the main-array in such a way that the change-over from the use of the sub-array to the full VLTI requires a minimum of steps.

Although such an integrated approach may appear obvious to the reader, it is by no means an uncontroversial, obvious philosophy to everyone in the interferometry community. There first is the skepticism by many about the actual availability of the 8-metre telescopes for interferometric imaging. Certainly, these large telescopes will not be available for a significant amount of the time for interferometric imaging until the astronomy community wants to use them for that. Before their use for interferometric imaging will successfully compete in time with other uses, a "user-friendly" capability for interferometric imaging with the VLTI has to be demonstrated. That will have to be done with the auxiliary telescope sub-array, which will also exploit ways of reaching the maximum possible sensitivity. It is our conviction that this can be done, and that the resulting user demand for the use of the 8-metre telescopes for interferometric imaging will follow. Second, the design of the 8-metre telescopes cannot be optimized for interferometry alone. Therefore, compromises are necessary which ripple through to the design of the entire VLTI, including the sub-array of auxiliary telescopes because of the philosophy described above. Certainly, an interferometer designed without the constraints associated with the VLT (site, fixed telescopes requiring the use of delay lines, alt-az mounts, limited number of telescopes, etc.) would in some aspects be more powerful than the VLTI. These advantages, however, fade in comparison with the power resulting from an interferometer with telescope apertures of 8 metres.

This philosophy is also directly in tune with that of the VLT Proposal in which two movable auxiliary telescopes are "joined" to the 8-metre array with the purpose of giving better (u, v) plane coverage and permanent interferometric usage. It is therefore perhaps not surprising that the panel's implementation plan resembles closely that of the proposal, going mostly into a more refined definition of the array components taking into account the need to optimize performance of the array for both on-axis and off-axis operation. The implementation plan shares such features with the original proposal as the number and size of auxiliary telescopes, the emphasis on long wavelength coverage, a significant (> 3 arcsec) interferometric field-of-view, beam combination in air, use of delay lines with a long stroke, and common usage of beam combiner (and probably delay lines) for 8-metre and auxiliary telescopes. Both implementation plan and proposal view the development of interferometry with the VLTI to be a gradual, step-by-step one. The plan, however, differs from the original proposal in some aspects: (i) it argues strongly for a configuration of the 8-metre telescopes which is more optimized for interferometry (see section 3.1), (ii) it provides for the expansibility of the array with more auxiliary telescopes and delay lines (to be provided by additional contributions by ESO member states), and (iii) it provides for the incorporation of adaptive optics in the auxiliary telescopes.

1.3 Why Large Aperture Interferometry?

In this context the question is sometimes asked on what is really gained by going to large aperture interferometers. Doesn't an array of many small telescopes do as well, or even better? The answer to this question is important because it determines the part of astronomy at which the VLTI will be particularly useful and for which it should be optimized. Although an increase in collecting area in astronomy is generally thought of as giving an increase in sensitivity, this is by no means obvious for interferometric imaging. It has been argued in fact that little is gained in limiting sensitivity by the increased aperture in the case of multi-speckle, broadband observations. This is the case at short wavelengths (up to the Johnson M band without the use of adaptive optics, up to the H band with the use of adaptive optics). The combination of the fact that the number of photons per speckle is independent of the telescope diameter D with the decrease of the maximum spectral bandwidth which can be used with larger apertures results in a very slow increase at visible wavelengths in sensitivity, it being proportional to $D^{1/3}$. The VLTI is therefore not well suited for that kind of observation, unless the larger "pre-resolution" provided by the individual 8-metre telescope apertures is of importance for the astronomical observation. Things change when spectral resolution larger than a few hundred is wanted. In that case the sensitivity of the multi-speckle observations increases as D^2, making it an important goal for the VLTI.

Larger gains with telescope aperture result in the single speckle mode which occurs without adaptive optics in the Johnson N band and above, and with the VLT adaptive optics at wavelengths as short as the H or K bands. In these domains the sensitivity increases proportional to D^4 for any spectral bandwidth. The entire infrared region is therefore an important region for the VLTI. As

[1] The VLT Interferometry Panel is composed of J.M. Beckers, R. Braun, G.P. Di Benedetto, R. Foy, R. Genzel, L. Koechlin, F. Merkle, and G. Weigelt, with A. Labeyrie, P. Léna, J.-M. Mariotti, and D. Downes as consultants, and D. Enard, M. Faucherre, H. van der Laan, and M. Tarenghi as observers.

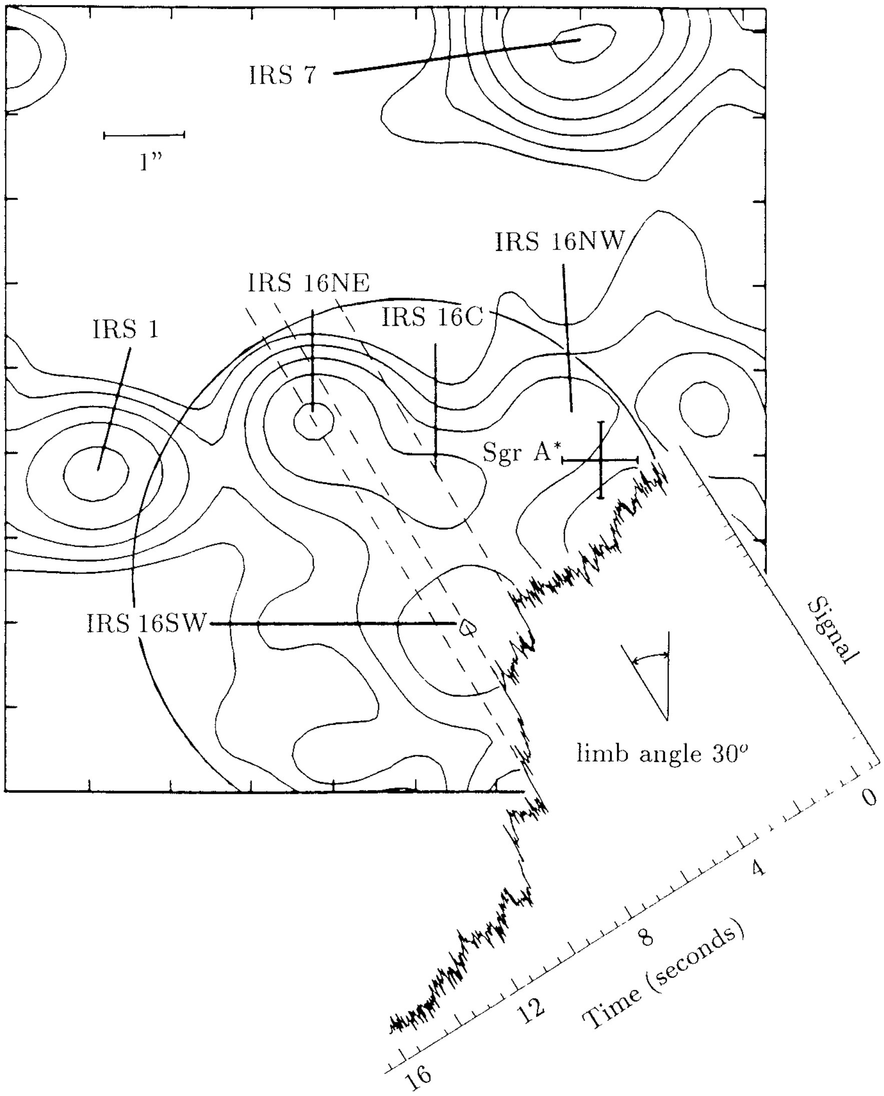


Figure 1: *Contour map of the Galactic Centre in the Johnson K band (2.2 μm) with an angular resolution of approximately 0.7 arcsec. The Galactic Centre is thought to coincide with the location of IRS 16 NW/Sgr A*. Superposed is the light curve due to an occultation by the moon and the resulting reconstruction of the fine structure in the IRS 16 area (shaded areas and dots in the circle). The angular resolution provided at this wavelength by the individual 8-metre telescopes (.055 arcsec) equals half the dot sizes shown at IRS 16NE and IRS 16E. The resolution of the VLTI exceeds that by a factor of 15 (.004 arcsec). Courtesy R. Genzel.*

an example of its potential application, Figure 1 shows an intensity map in the K band of the Galactic Centre, an area of particular interest at the VLT location. The presence of the very bright compact source IRS 7, only 5 arcsec away from the Galactic Centre, allows accurate sensing of the atmospheric wavefront disturbances needed for the VLT adaptive optics. This will result in direct very high angular resolution imaging (.055 arcsec) of the entire IRS 16 region (size of the isoplanatic patch ≈20 arcsec) with the individual 8-metre telescopes. This by itself demonstrates a very important feature of the use of a large telescope for interferometry because it allows the "pre-resolution" of features in a complex target like this one. Starting with the well-resolved images of the individual 8-metre telescopes, the VLTI will increase the angular resolution with another factor of 15 using the very high sensitivity coming from the 8-metre aperture. This sensitivity will be further enhanced by the possibility of real time sensing of the position of the interferometer fringes on IRS 7 which is probably unresolved by the VLTI, or another unresolved object in IRS 16, and subsequent fringe tracking. This allows long exposures, which gives signals exceeding the detector read-out noise even when using high spectral resolution. The Galactic Centre provides perhaps the finest demonstration of the VLTI power, and of the advantages gained with its large apertures. It is however not unique, similar examples can be given for other objects.

2. The VLT Interferometer: Are We Ready for It?

2.1 Current Efforts in Optical Interferometric Imaging

Figure 2 summarizes the properties of existing optical interferometers as well as those in the construction and planning stages. There are at this moment 6 operating interferometers available (GI2T, I2T, MARK III, MMT, Soirdete, Sydney).

The interferometers shown are broadband amplitude interferometers only, and do therefore not include the now discontinued Culgoora intensity interferometer and the 10.6 μm Berkeley heterodyne interferometer. All interferometers, except for the MMT, are non-monolithic interferometers (with the telescopes on separate mounts) requiring pathlength adjustments using e.g. delay lines. All existing interferometers routinely acquire fringes, often within minutes and, when well engineered, shortly after the start of the commissioning of the device. Technically, the viability of optical interferometry has therefore been amply demonstrated. These existing interferometers, generally of a prototype nature, have given us the confidence and expertise needed to go on with the many second-generation machines shown in Figure 2, which are now under construction or on the drawing board.

In contrast to most existing first-generation interferometers, which focussed on stellar size, binary star, and astrometric observations, these second-generation devices emphasize two-dimensional imaging using a number of simultaneous baselines, phase closure techniques, and other imaging methodologies taken from image synthesis efforts in radio astronomy.

2.2 Optical and Radio Interferometry: Similarities and Differences

The VLTI will rely strongly on the expertise gained with interferometric imaging in radio astronomy with interferometers like the Westerbork array, the VLA, MERLIN, the VLBI networks, and the Australia Telescope. Both optical and radio interferometry rely on the simultaneous measurement of the amplitude and phase of interference fringes over a number of different baselines as their basic observable. Algorithms for deriving astronomical images are therefore very similar, if not identical. The ways to arrive at the measurement of the interference fringes are however very different. It is instructive to compare these differences.

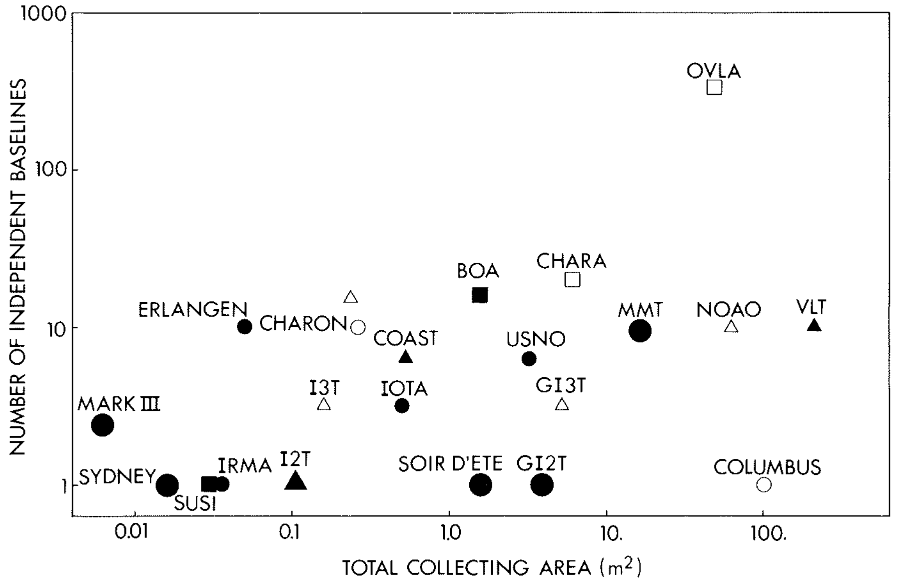


Figure 2: *Properties of Optical Interferometers. Large filled symbols represent existing facilities, small filled symbols those under construction, and open symbols those being planned. Circles for maximum baselines under 100 metres, triangles for maximum baselines between 100 and 300 metres, and squares for maximum baselines above 300 metres.*

The most obvious difference results of course from the very large difference in wavelength or frequency. This difference amounts to about a factor of 10^5. The much shorter wavelengths in optical interferometry places on the one hand a much higher demand on the dimensional stability and dimensioning of the array, but on the other hand allow angular resolutions comparable to that of the VLBI networks over baselines of only 100 metres. The much higher frequency of optical radiation (10^4 to 10^6 GHz) eliminates the use of heterodyne technologies with their limited bandwidth (< 1 GHz), except at the lower frequency end and when high spectral resolution observations ($R > 10^4$) are needed. Also, whereas in radio interferometry heterodyne techniques allow the use of electronic delays to compensate for the varying pathlength differences, optical interferometry has to use optical delay techniques.

Also the effects of the earth atmosphere are very different. Only at the very longest wavelengths will the VLT 8-metre telescopes be diffraction limited, whereas this is the case for all radio telescopes. The VLTI will therefore either work in the so-called multi-speckle mode at the very short visible wavelengths, or use adaptive optics to make the telescopes diffraction limited at the longer near-IR wavelengths. In the multi-speckle mode the fringe phase varies across the seeing image on the speckle scale. Recently developed methods using bi-spectral image analysis (or speckle masking) allow the measurement of the relative phases for the different baselines, needed for phase closure imaging, also in this multi-speckle case. In the diffraction limited, or single speckle mode, the relative fringe phase is well established and can be directly measured. Another difference caused by the atmosphere is the rapid variation of the fringe phase with time, in as little as 10 milliseconds at visible wavelengths. This implies the use of many observations with very short integration times, which sets a serious limit to the sensitivity of optical interferometers.

Then there are differences resulting from the different treatment of the radiation. Detection techniques at optical wavelengths are photon-noise limited except at near-infrared wavelengths where readout noise still dominates. At radio wavelengths detection noise is always detector limited. The difference in noise characteristics necessitates differences in measurement reduction techniques. Another difference is the ability at optical wavelengths to build interferometers with a wide interferometric field-of-view[2], giving interference over a field comprising many ($> 10^4$) Airy disks, allowing e.g. the use of IRS 7 near the Galactic Centre (Fig. 1) for fringe position monitoring or tracking. Radio interferometers limit themselves generally to one Airy disk using one "feed", although multi-feed systems using a few Airy disks are now in development.

Radio and optical interferometry thus share much, including the intellectual challenges associated with developing high-resolution imaging techniques, but also differ in many aspects. Initial differences relating to the different languages and cultures of the two fields of endeavour have been resolved, and a fruitful interaction and active participation has developed.

2.3 *Adaptive Optics: An Important Part of the VLTI*

The largest gains in sensitivity of the VLTI will come from the incorporation of adaptive optics which will make the telescopes diffraction limited at near infrared wavelengths (≈ 2 μm). All radiation from an unresolved source collected by the 8-metre telescopes will then be combined in phase, in the area of a single speckle of the size of an Airy disk. The recent spectacular success with the VLT adaptive optics prototype developed in a collaboration of French research institutes and ESO (see F. Merkle et al., in the *Messenger* No. **58,** p. 1, and also on page 9 in this issue) promises the successful incorporation of adaptive optics in the VLT early in its commissioning. Its application will predominantly be determined by the availability of stars within the common-phase field-of-view, or the so-called isoplanatic patch. Wavefront sensing in the visible and near IR (2 μm) will result in full sky coverage at about 5 μm wavelength and above, and major sky coverage at shorter IR wavelengths (e.g. 100% for the central areas of the Milky Way at 2 μm). Present experiments using artificial, laser-generated stars for wavefront sensing, promise to extend full sky coverage of adaptive optics systems to shorter wavelengths (1 μm).

These lower wavelength limits to the utility of adaptive optics refer to the combination of all the collected radiation in a single speckle. But at shorter wavelengths an adaptive optics system built for e.g. 2 μm (as is planned for the VLT) will not suddenly fail to function, instead it will become a so-called partial adaptive optics system. In this mode, computer simulations show that a fraction of the light (5 to 10% at visible wavelengths) will still be combined in a single central bright speckle with the rest remaining distributed over the multi-speckled seeing image. Even this minor concentration in the partial adap-

[2] In the following I will distinguish clearly between so-called interferometric and unvignetted field-of-views. For an unvignetted field-of-view the light from the different parts of the entrance pupil arrives at the beam-combining station unvignetted, but not necessarily in a condition to allow interferometry between the different telescopes. An interferometric field-of-view has to be unvignetted, but in addition has to combine the rays from the different telescopes in phase (within a fraction of a wavelength, the so-called "phased field-of-view") or coherently (within the coherence length, resulting in fringes, the so-called "coherent field-of-view").

tive optics case can be shown to enhance the sensitivity of the VLTI at shorter wavelengths very much. As is the case for full adaptive optics at near-IR wavelengths, it is realistic to expect the availability of partial adaptive optics for visible light, covering a major part of the sky, early in the lifetime of the VLT, since they use the same wavefront sensing and correcting systems.

3. The VLT Interferometer: Current Plans

3.1 The Array of 8-metre Telescopes

As described already, the philosophy in the planning of the VLTI focusses on the optimum implementation of the array of the four 8-metre telescopes. Therefore, that's what will be described first.

Telescope Configuration

The quality of full two-dimensional interferometric imaging very much depends on the simultaneous availability of many interferometer baselines in all directions of the compass. It is important for interferometry with the VLTI to optimize the configuration of the 8-metre telescopes in this respect even in the presence of movable smaller telescopes. The reasons for that have to do with both the sensitivity of the VLTI and with its potential for being used in a wide interferometric field-of-view mode.

At infrared wavelengths, where the telescopes will be diffraction limited, the maximum sensitivity in the imaging mode of an interferometer using different aperture telescopes results from matching the size of the Airy disks. That results in different image scales, and results in a "zero" field-of-view (restricted to the size of the Airy disk). The sensitivity for on-axis interferometry becomes in that case proportional to D^2d^2, where d equals the diameter of the smaller telescope. With a d = 180 cm auxiliary telescope this results in a 20 times lower sensitivity as compared with the use of a pair of 8-metre telescopes. When Airy disks are not matched (e.g. when a wide interferometric field-of-view is wanted) and when working at the shorter wavelengths, the sensitivity is much larger (100 times and more).

For observations of the faintest objects, it is therefore very important to have access to the array of 8-metre telescopes optimized for interferometric imaging. The array as described in the VLT proposal is, however, far from optimum. It consists of the four telescopes in an approximate EW line, with very

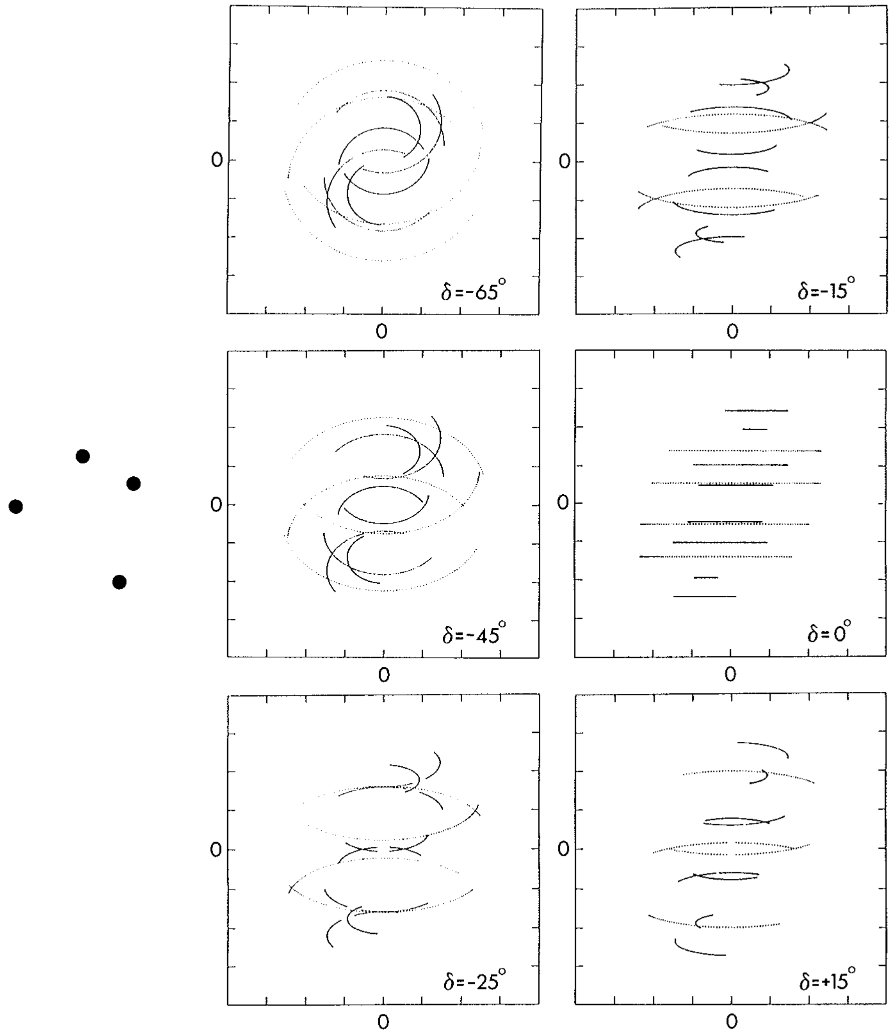


Figure 3: *Proposed configuration of the VLT 8-metre telescopes and the resulting (u, v) plane coverage for different declinations δ and for zenith distance angles up to 60 degrees. The base of the trapezoid has a length of approximately 120 metres. North is up.*

redundant spacings resulting therefore in only 3 or 4 simultaneous baselines in a direction which makes two-dimensional imaging virtually impossible, especially for regions at the lower declinations like the Galactic Centre (Fig. 1). The VLT Interferometry Panel therefore strongly argues for a quadrilateral configuration for the VLTI approximately in the form of an equilateral trapezoid. Figure 3 shows the configuration which is suggested and the resulting (u, v) plane coverage for different declinations δ.

This array has a total of 6 simultaneous, non-redundant baselines and results in a good two-dimensional (u, v) plane coverage for objects anywhere in the southern sky. These properties are little dependent on the precise orientation and baseline length of the array, so that it can be fitted to the VLT site. Site considerations will determine however the final configuration chosen, as will be the estimates of the deteriorating effects of the wind flow of telescopes on its neighbours. More on this later.

How to Get the Light to the Combined Coherent Focus?

Figure 4 shows the way in which the light from the individual telescopes will be combined in the VLTI beam combiner.

At each coudé focus of the telescopes the relay optics create an afocal beam with a diameter demagnification M of 100, resulting in an 8-cm diameter horizontal light beam being sent to the beam-combining system. The combination of the light in an interferometer has to occur according to stringent conditions if the performance of the interferometer is not to be compromised. To maintain maximum fringe contrast, the optics has to be of high quality and the polarization effects (retardation effects and direction changes) have to be identical in all light paths. The requirement that the rotation of the polarization directions have to be identical also results in identical orientations of the combined images as well as of the exit pupils. This

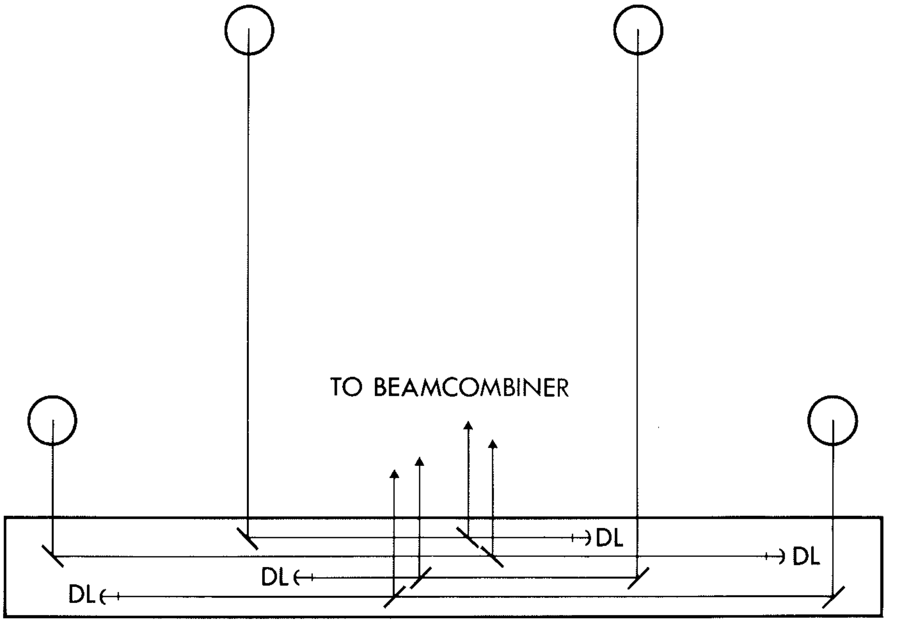


Figure 4: *Beam-combining scheme proposed for the VLTI. The afocal light beams from the coudé foci of each of the four individual telescopes are relayed to the interferometer tunnel (the long rectangular horizontal box) in underground light tubes located at right angles to the interferometer tunnel. The latter contains the delay lines (DL) for pathlength adjustment. The output of the delay lines is relayed to one of two beam-combining laboratories located on either side of the interferometer tunnel.*

is an important condition if the VLTI is to be operated in the wide interferometric field-of-view mode. The proposed beam-combination scheme follows these beam-combination conditions all the way from the telescope Nasmyth focus to the beam combiner.

Beam combination in the VLTI will occur in air. This decision is based both on arguments related to cost and operational complexity of an vacuum system of this size, as well as an evaluation that the effects of air in the light path can be managed at an acceptable level. There are five effects of concern: (i) image deterioration due to seeing for on-axis beams. This effect is lessened because of the large demagnification (M = 100) of the beam diameter making the effective Fried's parameter r_o M = 100 times larger, (ii) deterioration of the isoplanatic patch size due to the increase in angles by M = 100. An evaluation indicates that this effect is just acceptable for the interferometric field-of-views under consideration, provided that the seeing is carefully managed, (iii) pistoning of the light phase due to seeing, even if the effective r_o is large. These phase variations have to be compared to those of the free air above the telescopes, and can be made small and slow enough by shielding the light path from the wind, (iv) scintillation effects, which disappear when the pupil is reimaged onto the beam combiner, and (v) the so-called "longitudinal chromatic aberrations". The latter result in the change of the optical pathlength in the beam-combining optics from the geometric pathlength due to the finite refractive index of air. Lightpath differences in air of 100 metres will occur, resulting in changes of as much as 20 mm, a change which is wavelength-dependent, thus complicating broad spectral band observations. To compensate it, the VLT will use refractive optics of moderate size.

Description of the Delay Lines

Figure 5 shows the optical schematic of the Cat's Eye delay line optics which is envisaged for the VLTI.

The afocal light beam entering from the left is imaged by M_B on M_A, and recollimated by M_B to exit towards the left. Its dimensional and angular characteristics are preserved, and are quite insensitive to tilts and displacements of the Cat's Eye optics. Because the EW distances between the telescopes amount to as much as 120 metres, long tracks for the delay lines will be needed. These 60-metre-long tracks combined with the requirements for the size of the optics, their smoothness and accuracy of motion, as well as their dead reckoning positioning pose a major challenge to the implementation of the VLTI. The size of the Cat's Eye is determined by the unvignetted field-of-view required. Because of the M = 100 times angular magnification 8 arcsec on the sky results in 1/250 radian in the interferometer tunnel. With a pupil image as far as perhaps 75 metres away, this results in a beam size on the Cat's Eye entrance and exit of 38 cm diameter (8 cm inherent on-axis beam diameter, combined with 30 cm beam expansion). For a lower cost alternative, a 2-arcsec unvignetted field-of-view is also under consideration with a 15.5-cm beam diameter.

The small secondary mirror M_A in the delay line can serve a number of other functions. In the MARK III interferometer it is mounted on a piezo-electric actuator so that it can be used for rapid, small-pathlength adjustments. Also for a number of reasons it is desirable to make an image of the pupil at the entrance of the beam combiner. By making M_A curved it can do that without affecting the image relay or the afocal character of the optics. Since the delay line moves in position this curvature has to be variable making it a "zoom mirror". Techniques exist for accomplishing this.

The Beam-combining Station(s)

Interferometric beam combination can take many forms including combination in the pupil plane, in the image plane, and electromagnetic interference in the coupling between single-mode fibers. Each way has its advantages and disadvantages, and the mode chosen depends often on the type of observations wanted. Other forms of beam

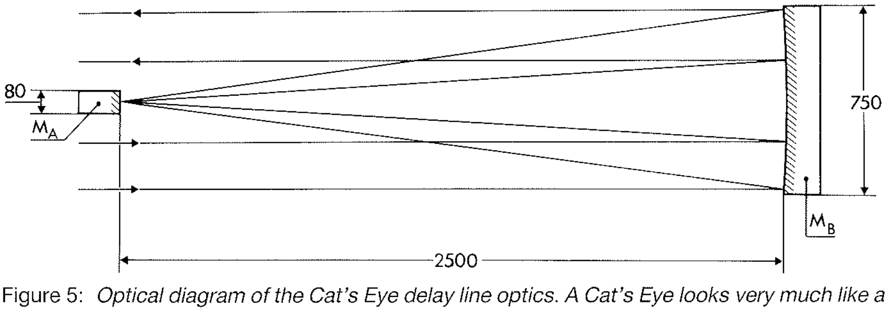


Figure 5: *Optical diagram of the Cat's Eye delay line optics. A Cat's Eye looks very much like a telescope with M_B as the parabolic primary mirror, and the little mirror M_A located in the prime focus as the secondary mirror. The dimensions of this delay line are for an 8-arcsec unvignetted field-of-view. A 2 arcsec field-of-view requires about half the size.*

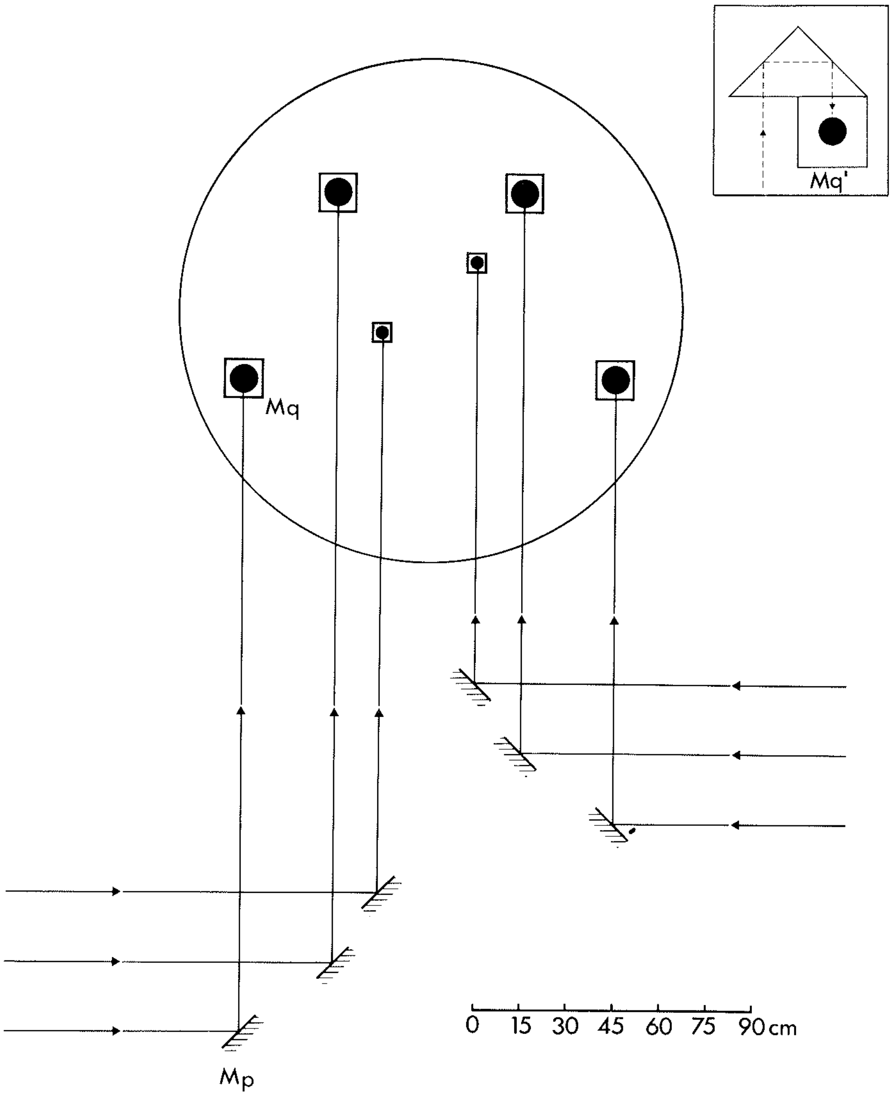


Figure 6: *Possible configuration of the on-axis light beams or pupil images at the entrance of the beam-combining telescope. The four large dark circles are the beams of the 8-metre telescopes, the small ones those of the auxiliary telescopes. The beams/pupil images are positioned by linear movement of the flat mirrors M_p, which send the light horizontally into the beam-combining laboratory, and by movement of the flat mirrors M_q which transfers the light downward into the beam-combining telescope. M_q is replaced by $M_{q'}$ in case it is desirable to rotate the image and/or pupil over 180° (as is the case when combining telescopes located on opposite sides of the interferometer tunnel).*

combination will undoubtedly arise in the future. For the VLTI it is therefore impossible to define the characteristics of the final beam-combining station now. Instead it is proposed that the VLTI provide for two stations, one containing an optical laboratory for experimentation, the other containing a fixed beam-combining telescope with an aperture between 80 and 180 cm. The latter will provide for common user image plane interferometric capability, including the capability for doing spectroscopy and, perhaps, wide interferometric field-of-view observations.

Figure 6 shows a possible combination of the light beams on the entrance of the beam-combiner telescope.

The actual configuration of the beams/pupil images on the beam-combining telescope can be determined by the actual observation wanted. Examples are:

(i) for spectroscopy a linear non-redundant (e.g. spacings 10, 20, and 40 cm of the 8-cm-diameter pupil images) configuration may be optimum. It results in a pattern of parallel fringes in the image plane whose spacing encodes the telescope pair and whose contrast and relative phase can easily be examined with a spectrograph simultaneously for many wavelengths. A configuration like this can use a stationary configuration of M_p and M_q, requires only an 80-cm aperture beam combiner, but suffers in respect to wide interferometric field-of-view operation. Its pupil configuration is not preserved, thus giving a "zero" field-of-view.

(ii) for wide interferometric field-of-view operation it is necessary to preserve the pupil configuration in detail from the entrance to the exit pupil. This places stringent but realizable requirements on the location of the pupil images, a location which changes with time, as the entrance pupil as seen from the star, changes with earth rotation. Motion of the M_q mirrors is more complex now and the beam-combining telescope has to be large enough in aperture to cover the area of the VLTI site demagnified by M = 100, resulting in an approximately 180-cm diameter mirror.

3.2 The Auxiliary Telescopes

So far the use of the 8-metre telescopes has been emphasized and the definition of the VLTI main-array has been based on it. As described in section 1.2, the definition of the sub-array of smaller 2-metre-class auxiliary telescopes (d = 180 cm is assumed here) is based on its incorporation into the main-array. That results both in an ease of change-over from the sub-array to the main-array, in a commissioning and debugging of the VLTI using the always available sub-array, and in a maximizing of the number of affordable auxiliary telescopes given the limited budget available for the VLTI. This results logically in the following definition of the VLTI sub-array (or VISA).

Telescope Configuration

The auxiliary telescopes are movable telescopes. It is proposed that they be relocatable between fixed stations, similar as is the case for the radio Very Large Array and for the IRAM millimetre array. In Figure 7 a possible configuration of stations for the auxiliary telescopes is shown.

In this configuration the auxiliary telescopes share the interferometer tunnel, the delay lines and the beam-combining optics with the 8-metre telescopes. To change over from the 8-metre telescopes to the auxiliary telescopes requires the insertion or turning of a single flat mirror. Change-over can therefore be done within minutes. The add-on cost per auxiliary telescope is limited to the telescope itself and possibly its transporter.

The Auxiliary Telescopes

To simplify the change-over and the coupling to the 8-metre telescopes it was decided to use the same type of coudé optics and telescope mounting as used for the 8-metre telescopes. In doing so one can use again similar or identical control systems, image/pupil/

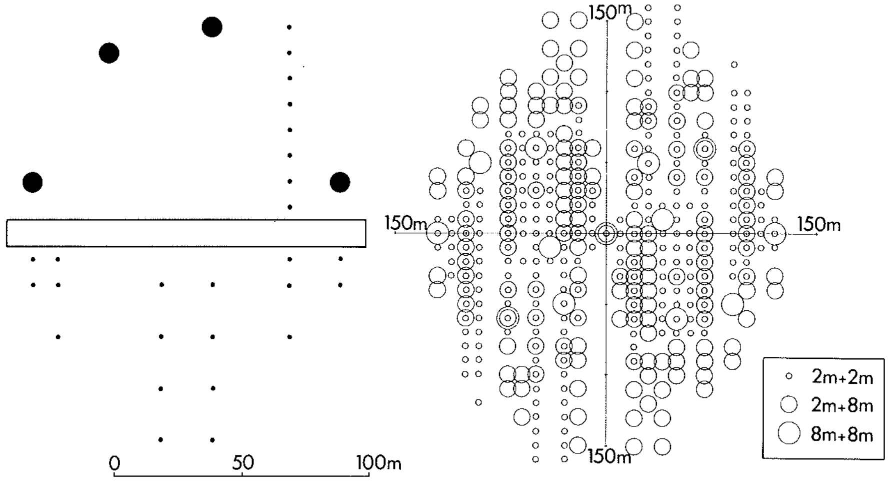


Figure 7: *Left: a possible configuration of the stations for the auxiliary telescopes (small dots). The assumed location of the 8-metre telescopes are shown with large dots (now slightly different from the configuration shown in Figure 4). The light from the auxiliary telescopes travels to the interferometer tunnel along the vertical lines which combines the stations. It anticipates therefore that only one auxiliary telescope can be used per vertical line. Additional stations on the lines connecting the 8-metre telescopes to the interferometer tunnel can also be envisaged. Right: (u, v) plane coverage options for object at zenith with the stations shown left. Note that in this case not all coverage is simultaneous as was the case in Figure 3.*

polarization orientations become the same, and retardation effects are comparable. The auxiliary telescopes include the option for relatively simple (as compared to the 8-metre telescopes) adaptive optics.

Telescope Transporters

Again following the example of the VLA and IRAM array, the telescope transporters will run along railway tracks. There will probably be one transporter per telescope which will lift the telescope from one station and place it on the next with good precision using a kinematic positioning system. The transporter will probably carry a wind shield as well as other telescope support equipment. Initially it is the intention to move the telescopes infrequently, like once per night. As experience with the VLTI develops, and as calibration techniques are refined, more rapid configurations (a number of times during the night) may become feasible.

3.3 Site Aspects

Which Site?

For the configuration shown in Figure 7 a flat plane is envisaged. To keep the length of the delay line as short as possible and to optimize the (u, v) plane coverage it is desirable to have the flat elliptical area with the short axis running roughly EW. This can be done at all VLT sites being considered (Vizcachas, Paranal and perhaps Armazones). The EW dimension of approximately 120 metres will pretty well be set by the need to space the 8-metre telescopes in that direction at right angles to the wind. From the VLTI point of view all three sites look acceptable although Armazones has the advantage of a larger NS extension as compared to the other sites for a given EW extension. This gives higher angular resolutions in that direction without the need for longer delay lines.

For a number of reasons it is advantageous to locate the VLTI on a flat area. On the longer term, large baselines may be wanted, which when located in approximately NS direction, can use the existing VLTI delay lines. In that case the additional telescopes (8 metres or smaller?) will probably be located at different levels, which does not exclude their use for interferometry.

Fitting the VLTI to the VLT Site

Figure 8 shows a drawing of the VLTI on Cerro Paranal following the layout shown in Figure 7.

The actual configuration for the VLTI will be chosen on the basis of the topography of the site chosen for the VLT, on the wind directions, on the seeing effects resulting from the interplay of the wind, the site plateau and the telescope structures, and on other VLT site needs. Interesting questions remain especially concerning the seeing effects which are presently being analysed (L. Zago, *The Messenger* No. **59,** p. 22). Such analysis will have to answer the question on whether the seeing for the 8-metre telescopes on the downwind end of the plateau is much worse than, or comparable to, that on the upwind end (no one expects it to be better!). If it is, the 8-metre telescopes will have to be located upwind, but at the cost of the probably much worse seeing effects for the auxiliary telescopes caused by the wind interactions with the 8-metre telescopes which are now upwind of the auxiliary telescopes.

4. The VLT Interferometer: What Comes Next?

Implementation of the VLTI will start with the site development after the choice of the VLT site. Extended Phase A studies of the major components of the VLTI (auxiliary telescopes, stations, tracks, transporters, delay lines) will be completed early 1991 and will be followed by their construction. It is desirable that interferometry using 3

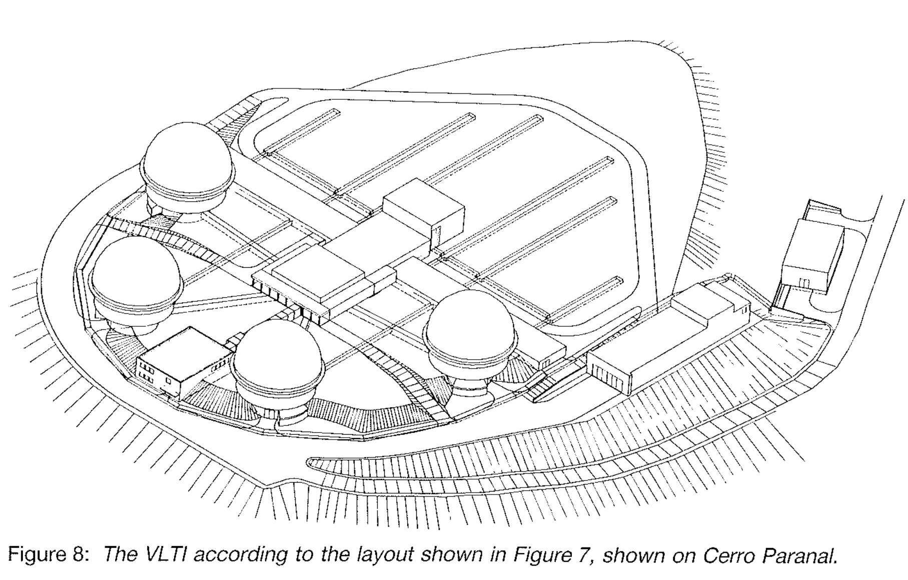


Figure 8: *The VLTI according to the layout shown in Figure 7, shown on Cerro Paranal.*

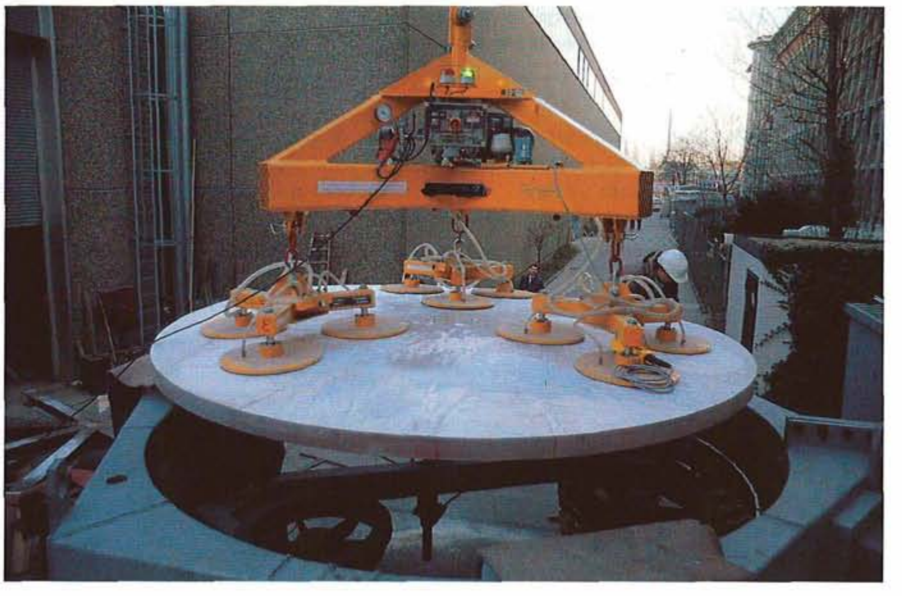
or 4 auxiliary telescopes (2 to be funded out of the VLT budget, the others by additional contributions by research groups in ESO member countries) and limited wavelength coverage (.45 to 25 μm) will start soon after the commissioning of the first large telescope on the VLT site. The full VLTI capability (including such features as the inclusion of the 8-metre telescopes, rapid reconfiguration of the auxiliary telescopes, a non-zero interferometric field-of-view, blind fringe acquisition and maintenance, extended wavelength coverage into the ultraviolet, additional auxiliary telescopes possibly at long NS baselines, additional delay lines) will evolve over a number of years after this, some of it requiring additional resources. The goal will be to provide early on at the VLT Interferometer a facility which will serve both the needs posed by the astronomical programmes of the non-experts in interferometry, as well as the needs of the experts in this rapidly developing field of astronomy. This is a tall task, but as it could be done for radio interferometry, it should also be possible to do it at optical wavelengths. The field is ready for it and the opportunity is here.

How Will the VLT Mirrors be Handled?

Schott is now putting the final touch to the building where the facility to produce the Zerodur VLT mirror blanks is to be installed. Meanwhile Schott is developing the various tools and equipment necessary for the casting, annealing, ceramization, machining and test of the mirror blanks.

Handling in particular is a major concern for Schott. The raw blanks obtained after casting are considerably heavier than the finished blanks and are also a lot more fragile because of the local defects at the surface which have a tendency to behave like perfect crack propagators. An additional difficulty is that after casting only the top surface is physically accessible.

Schott has therefore developed a special handling tool based on suction. The photograph shows a smaller-scale system developed to handle 4-m-diameter mirrors. It is being tested on an experimental thin meniscus realized in the frame of the VLT development programme. This mirror has been produced with the spin casting technology and was originally 4.1 m diameter. It has subsequently been machined down to 3.7 m diameter and to 7.5 cm thickness.



The picture shows the vacuum pumps located at the top and the large sucking cups arranged as a whiffle tree. The triangular structure is used as a vacuum buffer.

The tests have demonstrated the good functioning and the reliability of this type of handling device. Even in case of power failure the system can safely hold the mirror during several hours. A similar system is likely to be used for handling the mirror during its polishing and for its integration into the cell at the observatory. *D. ENARD (ESO)*

Adaptive Optics at the ESO 3.6-m Telescope

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G. ROUSSET, ONERA, France
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From April 11 to 16, 1990, the VLT adaptive optics prototype system has been tested at the 3.6-metre telescope on La Silla. After the two preceding test periods at the Haute-Provence Observatory in October and November 1989 (see the article by F. Merkle in *The Messenger* **58,** 1989) this was the first test of the adaptive optics prototype system at the telescope for which the system was initially designed.

A description of the prototype system has been given earlier (Merkle, *The Messenger* **57,** 1989). The following table summarizes the major data:

Wavelength range:	3 to 5 micrometre partial correction at shorter wavelengths
Deformable mirror:	19 piezo-electric actuators stroke: ±7.5 micron hexagon arrangement active diameter 70 mm
Tip/tilt mirror:	gimbal mount piezo-electric actuators
Wavefront sensor:	Shack Hartmann type 5 by 5 subapertures square configuration 100 by 100 intensified Reticon detector visible limiting magnitude 9 mirror for reference source selection
Computer:	dedicated processor 68020 host processor
Infrared camera:	32 by 32 InSb array additional chopping mirror
System concept:	bandwidth 10 Hz (100 Hz sampling) modal correction mirror eigenmodes polychromatic system

Some mechanical modifications had to be made at the prototype bench at the Cassegrain f/8 focus of the 3.6-metre telescope. In addition, the limiting magnitude was improved to about magnitude 9 for a 3.6-metre aperture by using as a first stage a proximity focus intensifier and a microchannel intensifier as the second stage. Further improvements are planned in order to achieve the theoretical goal of magnitude 12 to 13. After the mechanical integration of the system at the Cassegrain focus (see Fig. 1) it took approximately three hours to align it with the telescope, to perform the calibration and initialization with a real object on the sky, and to get the first, diffraction-limited image on the control monitor of the infrared camera.

This observing run at the 3.6-metre telescope was mainly aimed at:

- verifying the gain expected from adaptive optics with a large telescope,
- measuring the effects of partial correction by adaptive optics, and
- measuring the isoplanatic angles at various wavelengths and seeing conditions.

The intention of this short summary is only to give the reader a first impression of the type and quality of the results recorded. A detailed analysis of the more than 50 high resolution images covering the J-, H-, K-, L- and M-band with integration times ranging from approximately 10 seconds to 10 minutes – there was no restriction in integration

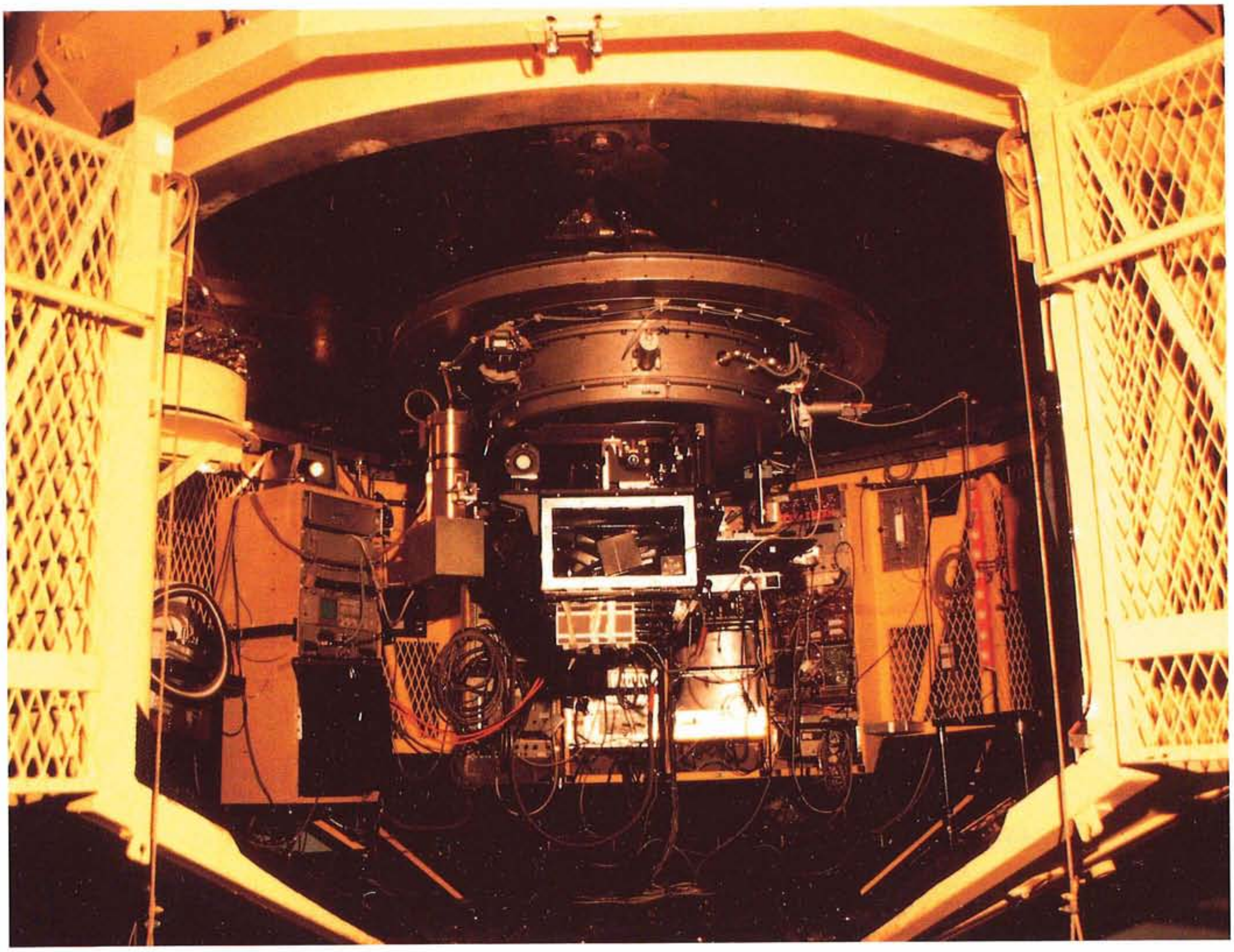


Figure 1: *The adaptive optics prototype system installed at the f/8 focus of the 3.6-m telescope. The rectangular frame is part of the optical bench that supports the system. To the left of the bench is the IR array camera and on the right side is the wavefront sensor support. The electronics rack attached to the left side wall of the Cassegrain cage houses part of the front-end electronics of the system.*

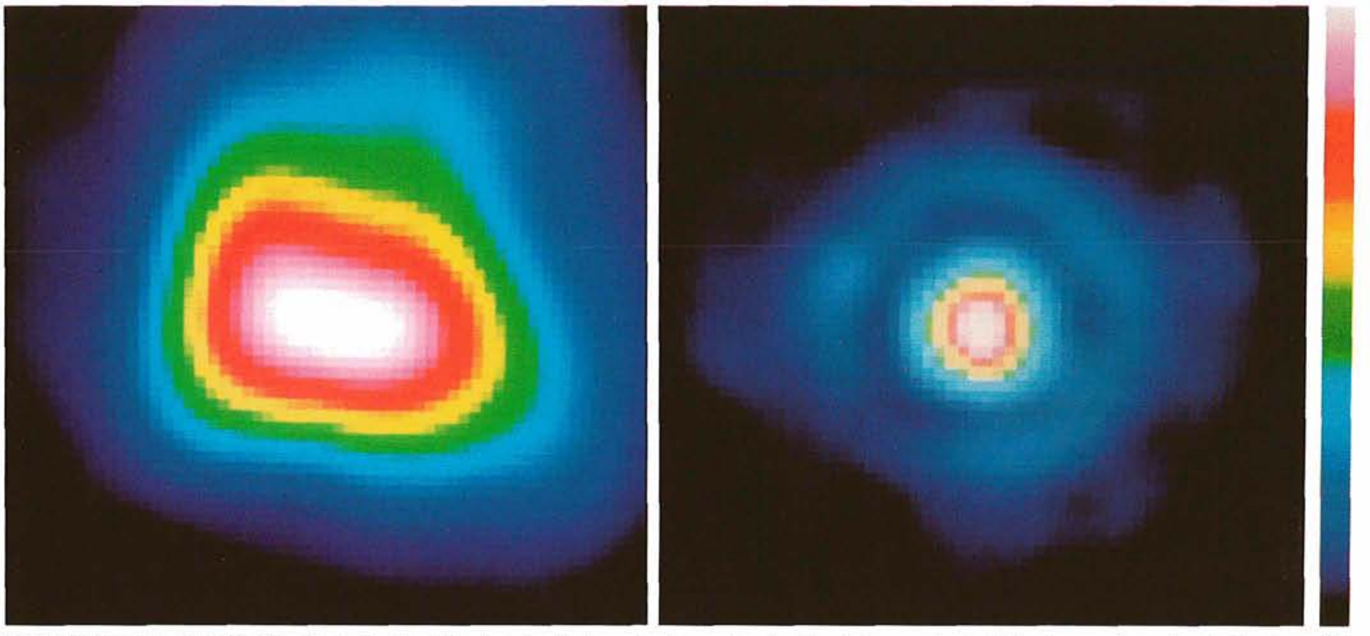


Figure 2: *Images of HR 6519 in the L-Band, without and with the adaptive optics feedback loop activated. The image diameter shrinks from 0.7 arcsec to 0.22 arcsec, which is the diffraction limit in the L-Band (3.5 μm).*

time – will take some time and will be published elsewhere.

Reference stars with magnitudes down to 9 could be used for the wavefront measurement and a spectacular gain in image quality can already now be reported.

The observed objects include bright, unresolved test objects to verify the performance of the system, independent of the object structure. In addition, a number of more complex objects of particular scientific interest were recorded, like η Carinae, some T Tauri stars, and various others.

Figure 2 shows the resolution gain when the real-time feedback of the adaptive system is activated for the object HR 6519 in the L-band. The uncorrected image (left) has a FWHM of 0.7 arcsec, the corrected (right) has 0.22 arcsec. The object served itself as reference for the measurement of the wavefront. Its visual magnitude is 4.81. The asymmetry of the uncorrected object is due to a problem with the 3.6-m autoguider which was detected during the observations. During the real-time atmospheric correction – the seeing was 0.9 arcsec in the visible range – this artefact was compensated in the same way as all other low-frequency telescope aberrations. The corrected image very clearly shows the predicted diffraction pattern. It still shows some imperfections which are due to some print-through of the actuators of the deformable mirror.

The images on page 1 show the improvement in image quality when the system is applied to the double star HR 6658 with visual magnitude 5.24 of the brighter component and 5.74 of the fainter one. The separation of the two components is only 0.38 arcsecs.

Apart from the evaluation of the performance of the system at the wavelengths for which it was designed, it was the aim of this test run to measure the effects of a partial correction by adaptive optics at shorter wavelengths. Figure 3 displays the image of the 4.7 mag star α Hydrae (HR 3748) in the J-, H-, K- and L-Band. The equivalent seeing in the visible wavelength range during the recording time was approxi-

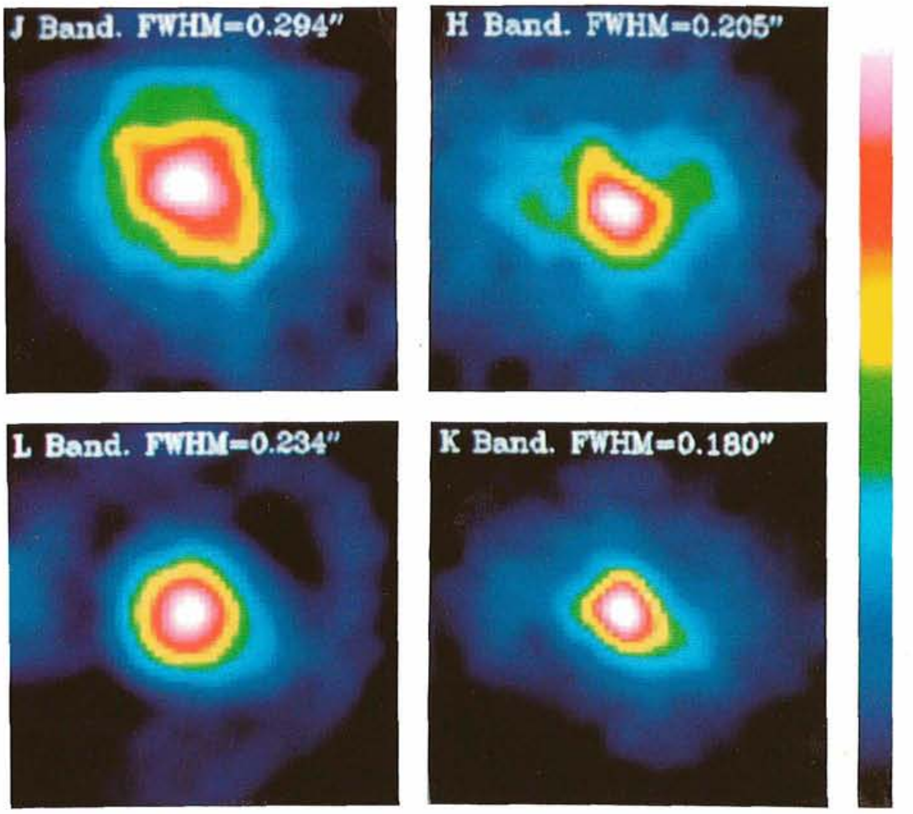


Figure 3: *Imaging of the star α Hydrae (HR 3748) in the J-, H-, K-, and L-Band with adaptive optics feedback. The dramatic image improvement is visible even in the J-Band where the system was undersampling at least by a factor of 2.5.*

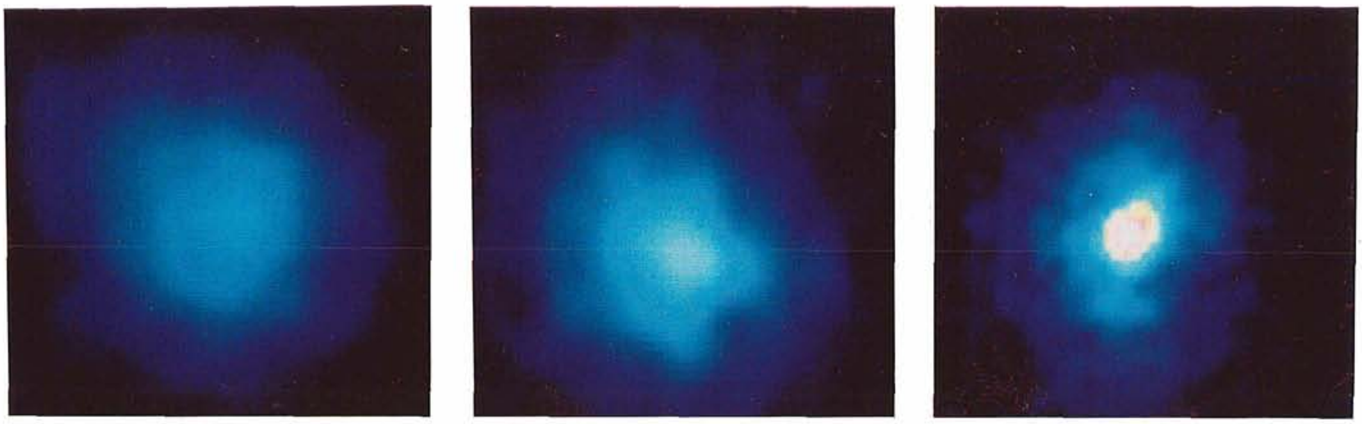


Figure 4: *This image shows an uncorrected image (left), an image corrected by the tip/tilt mirror (middle), and an image corrected by the tip/tilt and deformable mirror of the object HR 5646 (visual magnitude 3.87) in the K-Band. The object itself served as reference for the wavefront sensing. The Strehl ratio between the uncorrected and the tilt corrected image improved by a factor of 1.3, the gain to the fully corrected image is by a factor of 3.5.*

mately 0.75 arcseconds FWHM. The image improvement is dramatically evident even down to the J-Band where the system was undersampling, at least by a factor of 2.5. This corresponds to an improvement from 0.56 to 0.23 arcseconds (theoretically smallest possible value, i.e. the diffraction limit: 0.22 arcseconds) in the L-Band, from 0.58 to 0.18 arcseconds (limit: 0.13 arcseconds) in the K-Band, from 0.6 to 0.21 arcseconds (limit: 0.10 arcseconds) in the H-Band, and from 0.66 to 0.29 arcseconds (limit: 0.07 arcseconds) in the J-Band. This improvement at shorter wavelengths will be an important feature for interferometry with the VLT. The evaluation of the partially corrected images will help to build an analytical model for partial correction by adaptive optics.

Another important part of this test run was to measure the contribution of the image motion stabilization with the tip/tilt mirror in comparison to a full correction. Figure 4 shows an uncorrected image (left), an image corrected by the tip/tilt mirror (middle), and an image corrected by the tip/tilt and deformable mirror of the object HR 5646 (visual magnitude 3.87) in the K-Band. The object itself served as reference for the wavefront sensing. The seeing in the visual region varied between 0.7 and 0.85 arcseconds at the time of these measurements. The maximum intensity (Strehl ratio) between the uncorrected and the tilt corrected image improved by a factor of 1.3, the gain to the fully corrected image is by a factor of 3.5. This gain is limited due to the partial correction, since these measurements are taken in the K-Band at 2.2 micrometre.

Another important aim was the measurement of the isoplanatic angle as a function of wavelength, seeing, and order of correction. The system allowed offset angles between the object and reference source of up to 35 arcseconds.

As mentioned above, a detailed analysis of all results is now underway. This preliminary presentation of some of the most important results is only a brief introduction to the spectacular improvements which can be expected from adaptive optics at a large telescope.

What's Next in Adaptive Optics?

During the past half year it has been demonstrated that adaptive optics is a proven technique for high-resolution imaging in the near-infrared domain. The results obtained with the VLT adaptive optics prototype system give only a first impression of what will be possible in the future with systems with deformable mirrors with several tens or even hundreds of subapertures, compared to the 19 actuators the ESO system has today.

Adaptive optics devices are highly complex systems. The multichannel feedback loop requires very fast and powerful processors. Due to this complexity, adaptive optics systems are often considered as devices which are far from becoming a general user instrument of an observatory. It has frequently been assumed that only specially trained operators or the persons involved in the construction of the system can operate it and that it will therefore necessarily have quite a restricted use.

However, the observations with the VLT adaptive optics prototype system at the 3.6-m telescope have now made it quite clear that adaptive optics can become a tool which can be offered to any observer without special expertise. Although the current prototype is operated from three keybords, not including the infrared camera acquisition system (see the article by Merkle in the *Messenger* **58,** Fig. 4), the operation follows a clear procedure which could be taken over by an additional host computer. All functions can be automated without a major increase of the system's complexity. Also the optomechanical part, which at the moment still requires occasional human interaction, is now close to be completely remote controlled.

With the information and experience gained during the first test run at the 3.6-metre telescope, we are a big step closer to an "Adaptive Optics User Instrument for Infrared Wavelengths" which could be offered to any visiting astronomer. With the current plans to upgrade the prototype to approximately 50 subapertures, an adaptive system for full correction of a 4-metre-class telescope for the wavelength region above about 2 μm will become available. In the beginning it will be a bench-type instrument, but in less than three years it could be converted to a fully integrated system – as the "active optics" is already for the NTT.

F. MERKLE, ESO

Acknowledgements

The authors' thanks are due to many colleagues at ESO, Observatoire de Meudon, ONERA, and LASERDOT who have contributed to the design and construction of this prototype system. In particular, we are thankful to Claude Marlot of Observatoire de Meudon and the Mechanical Workshop at La Silla for "adapting" the adaptive system to the 3.6-metre telescope.

The ST-ECF After the Launch of HST

S. DI SEREGO ALIGHIERI, ST-ECF

One month after the launch of the Hubble Space Telescope (HST) the excitement is high among us at the Space Telescope European Coordinating Facilitiy (ST-ECF). We were able to follow the launch and the deployment of HST in real-time on the NASA "select" television channel, projected on the big screen in the ESO Auditorium and we are now closely monitoring the activities during the current Orbital Verification (OV) phase (an engineering check-out of HST).

With little surprise to those aware of the complications of the HST, a number of problems in the operation of the telescope have emerged and are under detailed examination. For example, the range of orientation of the high-gain antennae, which provide the high-speed data link to the ground via the relay satellites, is limited to 91 % of the whole sky by a cable harness. The effects of this limitation on the efficiency of the telescope can be made negligible by a proper scheduling of the observations. Considerable efforts are also being devoted to achieve a reliable procedure for pointing the HST. Successful guide-star acquisitions have been obtained, leading to a stable "fine lock", the most precise tracking mode of HST. Nevertheless, these successes are intermixed with failures to acquire guide stars, which have caused considerable disruption in the OV schedule.

On the positive side, all instruments have been turned on and are performing according to specifications or better, the Wide Field Camera has obtained the first images (with still warm CCDs) and the focus of the telescope is improving slowly but steadily. We are trying to keep the interested scientists informed about the progress with the HST by posting information from various sources on our HST bulletin board, which can be accessed from the outside by logging in into the captive account STINFO on the ESOMC1 Vax computer (no password needed). We are also answering questions concerning HST e-mailed to ESOMC1::STDESK (on SPAN) or to STDESK@DGAESO51 (on Bitnet).

Our direct involvement with HST data will grow in a couple of months, when OV will be completed and the engineers will hand over the telescope to scientists, so to speak, for the Science Verification (SV), a phase lasting about five months during which the performances of the instruments will be calibrated on celestial targets. SV is the responsibility of the teams that have developed the instruments and many of us will be closely collaborating with these teams in the effort of understanding the in-orbit performance of the instruments. In order to convey the results of this work to those European astronomers who are directly involved with HST data, we have set up three Special Interest Groups, connected with the Wide Field and Planetary Camera, the Faint Object Camera and the two spectrographs.

After SV the HST will finally start the scientific observations with the first one-year cycle of programmes already allocated to the instrument teams (the so-called Guaranteed Time Observers) and to the General Observers. If you wish to apply for HST observing time during the second cycle, look forward to the Announcement of Opportunity which will be issued by the Space Telescope Science Institute in Baltimore around the end of May 1990, with a proposal deadline no earlier than 15 November 1990.

PROFILE OF A KEY PROGRAMME

A Wide-Angle Objective Prism Survey for Bright Quasars

D. REIMERS, Hamburger Sternwarte, Universität Hamburg, F. R. Germany

Quasars are the most luminous objects in the universe which – not to speak about a growing interest in understanding these luminous active nuclei of galaxies themselves – can be used as light sources that probe the intervening matter at large cosmic distances early in the history of the universe. However, the number of known QSOs, in particular at high redshifts, which are sufficiently bright for detailed follow-up observations is extremely small. So, e.g., although several thousand QSOs are known at present, the only high-redshift QSO sufficiently bright for the short-wavelength camera of the IUE satellite, and as such a prime (accepted) target for the Hubble Space Telescope, was discovered only in 1988 by the Hamburg Quasar Survey with the Calar Alto Schmidt (HS 1700 + 6416, $V = 16.1$, $z = 2.72$, Reimers et al., 1989).

One of the reasons for the rareness of such objects is that pure UV excess surveys like the Palomar Green Survey do not find QSOs with $z > 2.2$ and that because of the low surface density of such objects, wide-angle multicolour or objective-prism Schmidt surveys are necessary. A further more practical requirement is the ability to process a larger number of Schmidt plates on a reasonable time scale, i.e. quick search methods are needed.

Bright quasars ($V < 17$) can be used for multiwavelength studies of the quasar phenomenon itself. At sufficiently high redshifts, quasars with absorption lines can be observed at high resolution (~0.2 Å), e.g. with CASPEC, as a tool to study the intervening matter with the aim to learn about large-scale structure, evolution of galaxy halos and galaxies, and chemical evolution of the universe. It has turned out that a spectral resolution of 10^5 may be required to resolve narrow absorption-line systems. Fairly bright QSOs will therefore be required even for the VLT, and here is one of the long-term goals of this Key Programme: to provide a sample of high redshift QSOs for detailed absorption-line studies with the VLT.

A further motivation comes from the finding of J. Surdej and collaborators – cf. the ESO Key Programme on gravitational lenses (Surdej et al., 1989) – that the success rate of finding gravitational lense effects is particularly high in high-luminosity quasars (HLQ) with M_v

< -29. This means, e.g., that all QSOs with $z > 1.7$ and $V < 17$ are candidate objects which can be checked on multiplicity with the superior angular resolution of the NTT.

Bright high-redshift QSOs offer also the possibility to study the quasar EUV with HST. For $z > 2.8$, both HeI 584 Å and the Lyα of HeII at 304 Å and the corresponding HeI and HeII absorption "forests" are in principle observable with HST. HS 1700 + 6416 just missed the minimum redshift for HeII 304 Å.

Finally, it appears that existing quasar surveys are quite incomplete at the bright end. We recently found with HS 0624 + 6902 ($V = 14.2$, $z = 0.37$) the brightest ever optically discovered QSO (Groote et al. 1989). This particular QSO has a strong "little blue bump" – a well-known excess emission in some QSOs due to FeII and the Balmer continuum – shifted to ~4000 Å. It therefore would not have been found with pure UV-excess techniques. With the resolution of the ESO Schmidt objective prism the quasar would have been discovered easily through its Mg II emission line at 3840 Å. Further evidence for the incompleteness at the very bright end is the fact that the ratio of bright QSOs ($V < 15$) detected by optical to those by other means (radio, X-ray, IRAS) is 5 : 8, quite untypical for QSOs as a class.

In the last few years, an automated QSO search software for objective-prism plates has been developed at Hamburg Observatory and was successfully applied to plates taken with the Calar Alto Schmidt (the former Hamburg Schmidt, a slightly smaller "twin" of the ESO Schmidt).

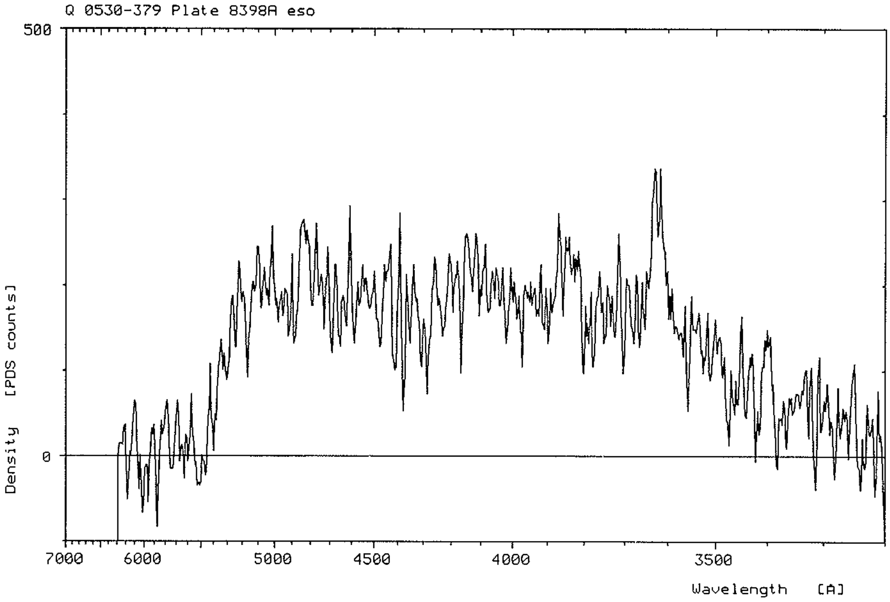
The plates are scanned with a PDS 1010 G in a low-resolution mode with on-line background elimination so that data are compressed to 5% (5 Mbyte) per plate. For details of the procedure I refer to Hagen (1987) and Engels et al. (1988). With a new faster amplifier of the PDS, developed by the Münster group, the scan time for a whole plate plus automated QSO search is only 4 hours. All spectra are stored on optical disks.

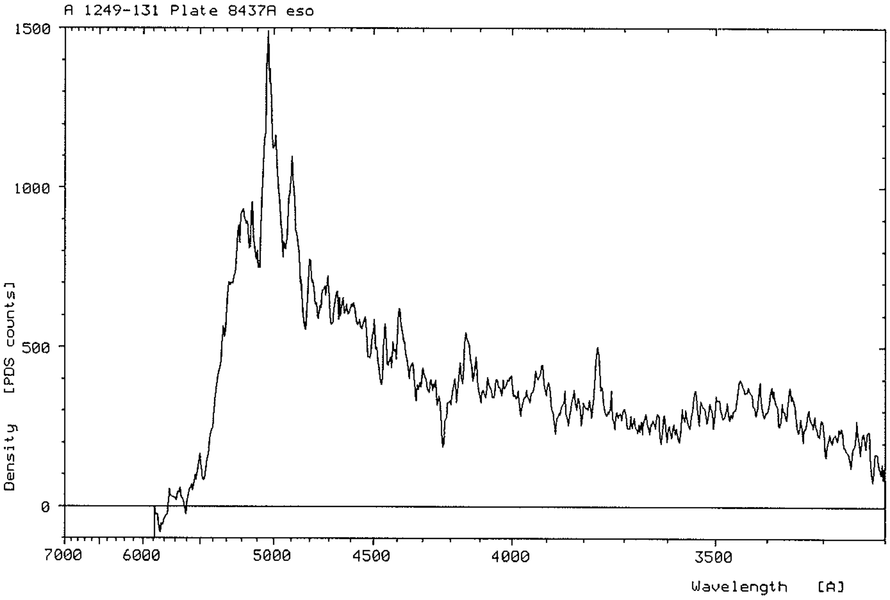
The software has been applied to and tested with the Calar Alto Schmidt plates, in particular an 8 square-degree field where we have identified 23 new QSOs to $V \approx 18.8$ by slit spectroscopy of all candidates. Altogether, several hundred new bright QSOs have been identified on the Northern Sky.

Since the ESO Sky Atlas is essentially complete, the time appears ripe to use the ESO Schmidt equipped with its prism (480 Å/mm) for a large-scale spectral survey on the Southern Sky in combination with automated techniques. The limit will be around $B \approx 18$. On 200 fields (≈ 5000 squ. degr.) – except a few test fields we aim at fields not covered by the the multicolour QSO Search Key Programme (Barbieri et al., 1989) or other surveys – we expect 50 QSOs with $V < 16$ (including about 20 for absorption line studies) and 400 QSOs with $V < 17$ (including 100 HLQs for a gravitational lense search). Hopefully 2 or 3 QSOs with $z > 2.8$ suitable for HST HeI and HeII line studies are among them. A side product will be large numbers of AGN ($Z < 0.08$) and emission-line galaxies, since contrary to other automated surveys, we start object selection on prism plates before star-galaxy separation. A further side product will be many new white dwarfs and hot subdwarfs. At the resolution of the ESO prism, WDs can be easily separated from subdwarfs, and rare classes like DBs (white dwarfs with only He lines) or magnetic white dwarfs may be recognized already on the prism plates.

The first high-quality prism plates for 12 fields have just arrived, and we look forward to see new exciting candidate objects.

Collaborators in this Key Programme are the gravitational lense group headed by Sjur Refsdal, Hamburg, the Liège quasar and gravitational lense group (J. Surdej and collaborators), both with interest in finding further bright lensed objects, J. Wampler (ESO) who would like to see new interesting QSOs sufficiently bright for high resolution spectroscopy of QSO absorption lines, and finally the stellar groups at Kiel and München for bright WDs and O subdwarfs as by-products.





ESO objective-prism spectra of a QSO (upper, z = 0.29) and an AGN (z = 0.01). Note that at the resolution of the ESO prism, OIII and H_β are separated.

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PROFILE OF A KEY PROGRAMME

A Photometric and Spectroscopic Study of Supernovae of All Types

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Supernovae are unpredictable events. For this reason, despite the fact that their interest spreads over numerous different fields, from stellar evolution to the interstellar medium and to cosmology, they have been observed, generally, with medium/small telescopes, whose schedules are flexible enough to ensure prompt observation of new objects. Therefore, the observations have been limited to the first months after outburst, and even in this period hardly on a regular basis.

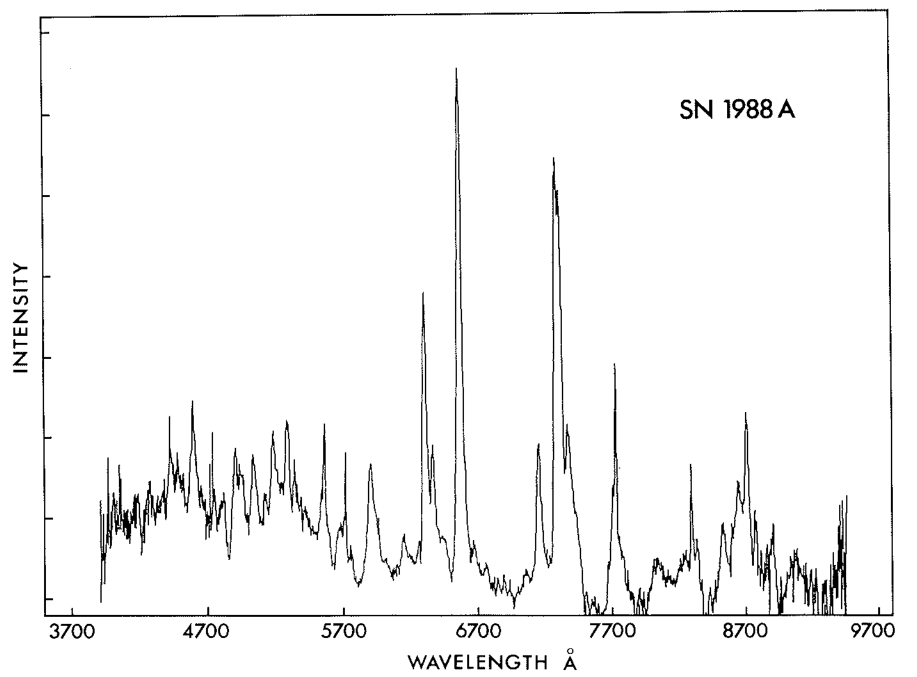
The recent experience with SN 1987A has demonstrated the large interest in this field of research including the ESO community, and also that it is possible to carry out successfully, even within a large structure like ESO, a programme needing regular observing for periods of years. Thanks to the use of appropriate equipment and to a dense temporal coverage approved by the OPC, astronomers at ESO have been able to announce a number of firsts, such as the discovery of molecules and dust formation, the temporal mapping of the ^{56}Co (+^{57}Co) decay (both from the bolometric light curve and the measurement of the Co II 10.52 μ line), the first order computation of elemental abundances in the envelope and the spectral characteristics of the just resolved shell around SN 1987A. There has also been much success in theoretical modelling of the expanding envelope.

Successful observations of a sample of SNe with modern detectors at large telescopes during a pilot programme started at ESO have also demonstrated that it is possible to follow photometrically and spectroscopically the evolution of SNe, other than the exceptionally close SN 1987A, for years (Fig. 1) and, at least in some fortunate cases, even for decades (Turatto et al. 1989).

In this framework, our Key Programme, dedicated to the study of the photometric and spectroscopic evolution of SNe of different types, has been proposed and approved at ESO. The general aim of the programme is to accumulate regularly spaced photometry, particularly for constructing bolometric light curves, and spectroscopy of SNe from their earliest announcement. At the same time, late-time spectra of already known SNe will be secured. It will be possible to store in a large unique database a great deal of material for a selected sample of supernovae. Emphasis will be put on observing a few objects in detail rather than many sparsely.

The regular allotment of telescope time over a span of years, awarded to the Key Programme, will allow us to address different questions.

From a quick inspection of the Asiago Supernova Catalogue (Barbon et al. 1989), it appears that the average rate of discovery in the last years is of about 20 SNe per year. Of these, about 6 are closer than 40 Mpc (H = 50 km/s Mpc) and reachable from La Silla. Whatever their type, all these SNe stay above the detection limit of EFOSC (or EMMI) for longer than 1 year in spectroscopy and 2 years in photometry. We will be able, therefore, to cover all phases of the optical evolution for several SNe of various types.



The EFOSC spectrum of SN 1988A at about 444 days after the discovery.

Although spectroscopy is available for several SNe Ia around maximum light, we still entirely lack bolometric luminosities and regular spectral observations beyond 150 days. It is not clear, in fact, how wide among various objects are the differences suggested both by spectra (Branch et al. 1988) and by light curves (Barbon 1980) and how they correlate with other parameters. This could be a problem for the frequent use of such objects as standard candles unless such differences can be accounted for and calibrated in a systematic way. For the less luminous and rarer Type Ib SNe, the observational status is at present even worse. Few objects have optical light curves, and bolometric information is completely lacking. Even the early spectral evolution is poorly known (because of sparse observations). Because the conditions in the envelope have not been clarified, since neither a spectroscopic temperature nor a thermal equilibrium calculation have been derived, the actual mass of oxygen has not been determined to within a factor of 10, preventing an accurate determination of the mass range of possible progenitors and their contribution to the chemical evolution of galaxies.

The heterogeneous class of Type II SNe represent another interesting field of investigation. In particular, we will try to understand if different shapes exist also in the bolometric light curves and to determine their total energy budget, which will lead to the determination of the total mass of radioactive ^{56}Co produced. Regularly spaced spectra of a number of objects will clarify whether all the documented differences are real or due only to the uneven spacing of the available information. If this variety represents differences in the envelopes of these SNe, it is not clear how this relates to the characteristics of the progenitor stars.

Beside the regularly spaced observations of newly discovered SNe, a special effort will be devoted to the identification and eventual observation of "very old" supernovae. There exists, in fact, an observational gap between the latest stages of SNe, which can be placed at about 2 years after the light maximum, and the youngest SNRs, whose ages are of the order of a few centuries. The optical detection of SN 1957D in M83 (Turatto et al., 1989; Long et al., 1989) and of SN 1885A in M31 (Fesen et al., 1989) indicates that it is possible to get precious information on the intermediate ages even with the presently available instrumentation. In particular, the spectrum of the 30-year-old SN 1957D in M83 shows broad [OIII] 4959, 5007 lines with asymmetric profiles and a velocity of the maximum emission of approximately −650 km/s relative to the rest velocity. This could be due to the presence of dust filling the line-forming region analogous to the situation found in SN 1987A. For this SN, unfortunately, early-stage observations are missing and an unambiguous classification is then impossible. However, there are about 70 SNe older than 10 years accessible from La Silla, which are candidates for detection. Although many difficulties arise when one tries to locate the very faint candidates inside the parent galaxy, even a small number of successes would constitute milestones in the understanding of the evolution of young SNR.

The collaboration with CTIO, with whom important coordinated observations have been obtained on SN 1987A, and with the Asiago Observatory, for the early stages of the SNe visible also from the northern hemisphere, should also ensure both a better temporal and spectral coverage.

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PROFILE OF A KEY PROGRAMME

Optical Follow-up Identifications of Hard X-Ray/ Soft γ-Ray Sources Discovered by the "SIGMA" Telescope

G.F. BIGNAMI, P.A. CARAVEO, S. MEREGHETTI, Istituto Fisica Cosmica, Milano, Italy

J. PAUL, A. GOLDWURM, L. VIGROUX, Service d'Astrophysique, CEA Saclay, France

P. MANDROU, G. VEDRENNE, J.P. ROQUES, CERS, Toulouse, France

The aim of this programme is to search for the optical counterparts of hard X-ray/soft γ-ray sources (including γ-ray bursts and transient events) discovered by the SIGMA telescope (successfully launched on December 1, 1989), also exploiting the soft X-ray data of the all sky survey to be performed by the ROSAT satellite (launched on May 31, 1990).

It will be the first time that coordination between on-going high-energy space missions, such as SIGMA and ROSAT, and ground-based telescopes is implemented on a programmed long-term basis.

The SIGMA telescope (constructed by two French groups at CEA/Saclay and CESR Toulouse) aboard the Soviet GRANAT satellite represents the first breakthrough in one of the last unexplored wavelength regions in astronomy. Launched on December 1, 1989, it consists of a gamma camera/coded mask telescope system (see Fig. 1) separated by 2.5 m, with imaging capability yielding a source localization accuracy of 2′ within a field of view of $4\overset{\circ}{.}3 \times 4\overset{\circ}{.}7$ and a sensitivity in the milliCrab region. The energy range goes from 35 keV to 1.3 MeV, and operations, planned for two years, will be based on 10^5–10^6 sec. pointed observations of the 3-axis stabilized telescope.

After the mandatory outgassing period of the various SIGMA subsystems, more than two months of in-flight operations were required both to complete the telescope adjustment (a quite difficult task, taking into account the 131 photomultiplier tubes of the gamma camera, the on-board calibration sources and the active shielding device), and to evaluate the background along the orbit. This is now stabilized on a rather constant value of 440 counts/sec, which compares favourably with the one computed on the ground of 320 counts/sec,

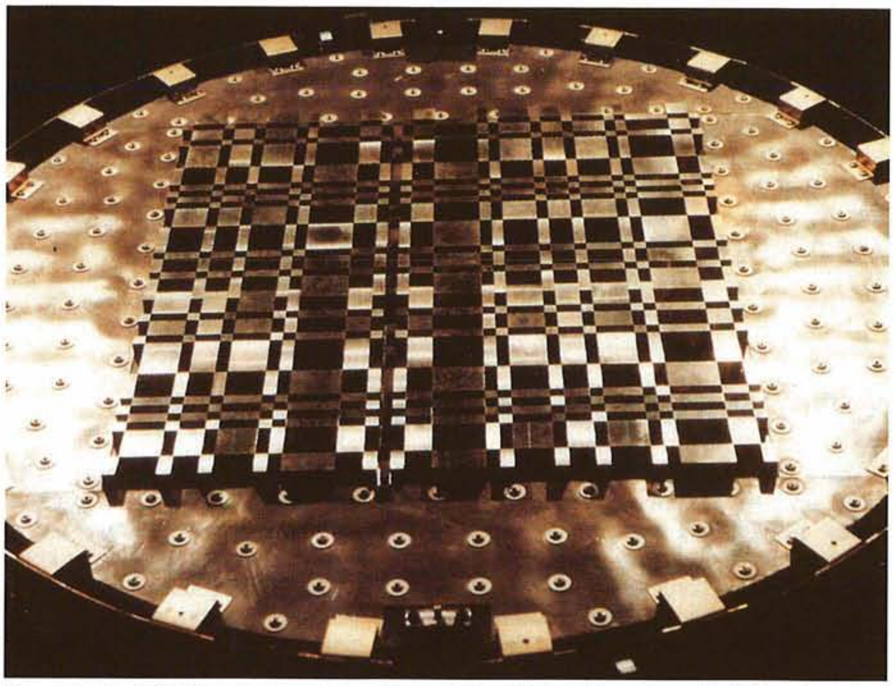


Figure 1: *The SIGMA coded mask. A pattern of 49 × 53 absorbing elements (1.5 cm tungsten) is arranged in a URA (Uniformly Redundant Array), each element is 9.4 × 9.4 mm.*

considering the current high level of solar activity. At the end of this evaluation period, several Crab nebula observations were performed to assess the in-orbit capabilities of the telescope. Both this source and Cyg-X1 yielded a very strong signal permitting the preliminary localization of the position of these sources within a 2′ error box in a 4-h observation, with very high significance up to 300 KeV and more.

A different type of test was performed on the Galactic Centre, with the aim of disentangling a supposedly complex region of high energy emission. SIGMA has already provided the *first ever* arcmin resolution image of the galactic centre in the 35–120 keV region. While work is in progress to analyse in more detail the data which were taken on March 24, 1990, we are already in a position to say that at such high energy the region is dominated by emission from 1E 1740.7–2942, an unidentified Einstein source.

The SIGMA observations will yield results both on known X-ray sources, extending our knowledge of their spectrum, and on a wealth of new sources, galactic and extragalactic.

On the basis of what is currently known of the high energy emission from AGN's and their Log N-Log S, it is possible to predict the final yield of the SIGMA mission as several tens of new AGN's seen in the hundred of keV energy range.

In addition, the mission will study a great number of γ-ray bursts occurring during its operating lifetime, and few of them have already been observed. Thanks to the dimension of the fully coded field of view, several bursts will be observed through the imaging coded mask system, thus yielding, *for the first time,* an immediate localization with an accuracy of a few arcminutes and allowing a rapid coordination with ground-based optical observations. It is worth noting that the rectangular telescope field of view features a central area, in which the telescope is at its maximum, surrounded by a wide field of decreasing sensitivity (the half-sensitivity boundary is a 10°.6 × 11°.4 rectangle) within which sources can still be positioned within a few arcminutes.

In parallel to the SIGMA higher energy observations, the well-known ROSAT mission will work in the soft (.1–2 keV) X-ray domain, performing first a sky survey and then a sequence of pointed observations. The proposers of this ESO Key Programme have organized a collaboration between the two missions for exploiting the ROSAT survey data on the basis of the SIGMA results. This should result in an improvement of both source positioning and knowledge of spectral shape, rendering much more interesting and meaningful the search for the optical counterpart. Based on the proposer's experience in optical studies of γ/X-ray sources, the addition of the ROSAT data will be crucial to the success of this project especially for the search for an optical identification of newly discovered sources which is the most challenging, albeit the potentially most rewarding, part of the programme. The strategy here will consist in taking first CCD images of the source region in two colours, compare the images with

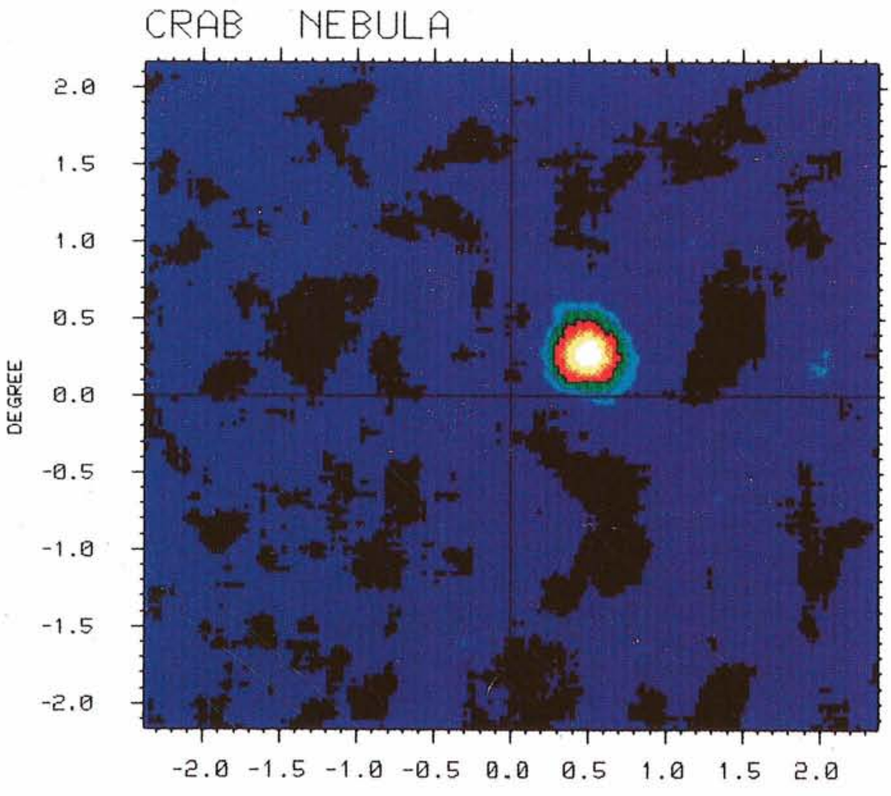


Figure 2: *First image (4 h exposure only) of the Crab (120–300 keV). The source is seen at very high confidence level and is positioned with a 2′ accuracy.*

all existing catalogues, hopefully find potential candidates and then resort to MOS spectra. Another useful dimension for identification is time variability on both long and short term timescales, as in the case of AGNs and X/γ-ray pulsars in our Galaxy. Polarimetry, also possible e.g. with EFOSC, on a complete source field, is yet another tool for identifying a high-energy, nonthermal candidate among normal field stars. This type of work has already been the subject of several programmes approved during the last four years for the ESO 3.6-m and NTT telescopes at La Silla. This has resulted in the successful study of several X/γ-ray source regions, carried out both in imaging/photometry, spectroscopy (including MOS), polarimetry and time variability.

We are confident that this Key-Programme team has both the observational experience and the organizational capability to fulfil the proposed scientific objectives for the first example of a ground based/high-energy space astronomy programme.

Report on the First ESO/CTIO Workshop: "Bulges of Galaxies"

The first ESO/CTIO Workshop was held on January 16–19, 1990, in La Serena, Chile. The scientific sessions took up 3 days with 2 afternoons reserved for visits to the La Silla and Tololo observatories. The theme of the workshop was "Bulges of Galaxies" and included all aspects of bulge research, both Galactic and in external galaxies.

There were eleven invited and about thirty shorter, contributed papers. A poster session was also provided. The meeting was attended by about 90 scientists from 5 continents. About 30, mainly young participants, were partially supported by the conference funds allowing them to attend and to present contributions.

The proceedings are being edited and will be published later this year by ESO.

It was a pleasure to work together with our colleagues from CTIO and it was good to hear many positive comments from the participants.

I hope that there will be many more such joint meetings held in Chile and that they may all be as stimulating as this one.

H.E. SCHWARZ, ESO

News About the ESO Exhibition

The travelling ESO Exhibition has a busy time this summer. Last year it was decided to duplicate most of the exhibition items, so that it can be shown in two places at once. This has paid off and both exhibitions are now booked out through most of 1991.

ESO was present, together with its sister organizations CERN, ESA and EMBL, at the "Europa Ricerca" exhibition in Rome, Italy on May 31–June 10. This major presentation of large European science and technology projects was organized by the Italian Chairmanship of Eureka in connection with the VIII Eureka Minister Conference.

It you visit Geneva in Switzerland this summer, don't miss a tour through the new CERN Microcosmos, just installed on the CERN grounds near Meyrin, outside the city. In addition to learning about the smallest particles, you will see beautiful pictures of galaxies and stars in one area of the Microcosmos building. Here the ESO Exhibition is installed until the end of August. It was inaugurated on May 28 by the Directors General of CERN and ESO, Professors Carlo Rubbia and Harry van der Laan.

The "Free University" of Brussels in Belgium will be host to the American Association of Variable Star Observers (AAVSO) this summer. This is the first time that this venerable American organization meets outside its home country, let on another continent. In recognition of this important event, ESO is setting up its exhibition at the University from July 17 to 29. There will be public access; more details can be obtained from the organizer, Dr. Chris Sterken, Free University of Brussels, Astrophysical Institute, Pleinlaan 2, B-1180 Brussels, Belgium.

ESO was pleased to accept an invita-

From the opening ceremony of the Eureka Minister Conference and the exhibition Europa Ricerca – (left to right) the Italian Minister for Universities and Technological Research, A. Ruberti, CEC Vice-President F.M. Pandolfi, ESA Director General R. Lüst and ESO Director General H. van der Laan. Participating in the ceremony were the Italian President, Francesco Cossiga, ministers and high representatives from the Eureka member countries and the EEC, directors general from CERN, EMBL, ESA and ESO as well as delegates to the conference.

tion to present its exhibition at the Council of Europe in Strasbourg, France, from September 26 to October 12. During this period, both the Council of Europe and the European Parliament will meet in this impressive building, situated in a park area near the centre of the Alsatian capital. This exhibition will not be open to the public, but it is expected that it will be visited by about 4000 delegates, media representatives and staff.

Next, ESO will show its face in the second-largest city of Portugal, Porto. The exhibition opens late September in the old steel-and-glass market hall which has recently been transformed into a perfect exhibition site. ESO's presence in Portugal is particularly timely in view of the current efforts to establish closer contacts between Portuguese astronomy and ESO. In mid-November, the exhibition will move on to the capital, Lisboa, where it is expected to stay until the end of the current year. Further information may be obtained from Prof. Teresa Lago, Grupo de Matematica Aplicada, Faculdade de Ciencias, Universidade do Porto, Rue das Taipas 135, P-4000 Porto.

Future exhibition sites include cities in Austria, Norway and Spain, as well as in South America; announcements of dates and sites will be made in the next issues of the *Messenger*.

12th European Regional Astronomy Meeting of the IAU

The preparations for this meeting (see the announcement in *Messenger* **59**, p. 25) are proceeding well and the organizers expect a large influx of European astronomers from all geographical areas of the continent. The meeting will start in Davos Kongresszentrum (Switzerland) in the early afternoon of Monday, October 8, 1990 and end around noon on Thursday, October 11, in order to facilitate travel on these days.

All prospective participants who have not already done so, are urged to contact soonest the Chairman of the Local Organizing Committee at the following address:

Professor Dr. U.W. Steinlin
Astronomisches Institut der Universität Basel
Venusstrasse 7
CH-4102 Binningen
Switzerland

or by email: EARN: SCHWENGELER@URZ.UNIBAS.CH;
SPAN: CHGATE::YOGI::SCHWENGELER.

Correspondence concerning the scientific organization should be directed to the Chairman of the Scientific Organizing Committee:

Professor Dr. L. Woltjer
Observatoire de Haute-Provence
F-04870 St-Michel l'Observatoire
France

Calendar:

July 15	Registration form to Dr. Steinlin
	Hotel reservation to Davos Tourist Office
Aug. 15	Abstracts of papers to Dr. Woltjer
	Fees must be paid to meeting account
Sept. 15	Third Circular with Final Programme
Oct. 8	Meeting opens in Davos: abstract book available

New Videos from ESO

Three new video films have recently become available from ESO:

- "Window to the Universe": A film about ESO made by the BBC. 24 min. Available in English, French, German and Italian.
- "The First NTT Images": A presentation of the first images from the NTT, obtained during the commissioning phase; made by the ESO Information Service. 9 min. Only available in English.
- "The NTT Inauguration": A summary of the main events and speeches during the inauguration of the NTT on Frebruary 6, 1990, in Garching and at La Silla. 24 min. Only available in English.

The videos are available on VHS, S-VHS, MII and Betacam on two cassettes; one with "Window to the Universe", while "First Images" and "NTT Inauguration" are on a common cassette. The price per cassette is 70.– DM. Orders should be placed with the ESO Information Service (address on last page). Please note that the delivery time will be about 4 weeks.

European Group of Astronomical Librarians (EGAL)

In July 1988 IAU Colloquium 110, entitled "Library and Information Services in Astronomy" was held in Washington D.C. This was attended by 120 people from 26 different countries, including several European librarians, most of whom met each other for the first time. Inspired by the stimulating talks and discussions, and the desire to transmit the "spirit of Washington" to other colleagues who were not able to attend, the idea of EGAL was born during the closing stages of the meeting.

On our return Suzanne Laloë (Institut d'Astrophysique, Paris) and myself distributed a report of the meeting together with a letter proposing the formation of an informal group of European librarians working in astronomical observatories and institutes. The response was encouraging and we decided to go ahead with our basic idea of distributing a newsletter 2 or 3 times a year and publishing a directory of names and addresses, telephone, telex, telefax numbers and e-mail addresses, plus a brief description of each library. The main aim is to foster informal cooperation and communication between librarians in all European countries, with a special emphasis on strengthening and improving links with our Eastern European colleagues. The possibility of also acting as a pressure group, for instance when problems with publishers or suppliers occur, is not excluded.

Initially about 70 librarians were contacted and replies were received from about 40. The first EGAL Bulletin, No. 0, a trial number, was mailed in May 1989 to all the librarians on our original mailing list. This brought in some more replies and we compiled the first version of the Directory. This was distributed, together with EGAL Bulletin No. 1, in October 1989, again to all the persons on our original list. It is hoped that EGAL Bulletin will become a forum for news, opinions, descriptions of libraries and routines, queries for help and information. Many observatory and institute libraries are relatively small and isolated.

Often there is only one person in charge of the library, and their feeling of isolation can perhaps be alleviated by the knowledge that there are several other people in a similar situation whom one can contact by telephone or computer. It must be stressed that the success of EGAL will depend on the willingness of the participating librarians to involve themselves actively via the Bulletin, by supplying items of news and information which could be of interest to other members.

The first two numbers of the Bulletin were produced and distributed with the help of the Max Planck Institute for Astrophysics, Garching. We are extremely grateful to ESO for its kind support in taking over the production and mailing from No. 2, March 1990 onwards.

We apologize to any librarian reading this who was not contacted and did not know about EGAL. Some names were deleted from our original mailing list because of failure to respond, but we will welcome any librarian who is willing to cooperate and share his/her experience and problems. There is no charge; so far we only exist through the medium of the Bulletin and the Directory. Sometime in the future it may be possible to organize some kind of meeting, but there are no firm plans as yet. Any European astronomical librarian who is not yet a member of EGAL and would like to become one is invited to contact me at the address given below.

A. FISHBURN
Astrobibliothek, MPI Astrophysik
Karl-Schwarzschild-Str. 1
D-8046 Garching bei München

ANNOUNCEMENT

The 4th ESO-CERN Symposium on

"Cosmology, Astronomy and Fundamental Physics"

and the 15th Texas Symposium on

"Relativistic Astrophysics"

will be combined into a joint Texas/ESO-CERN Symposium to be held at the Conference Centre in Brighton (U.K.), 16–21 December 1990.

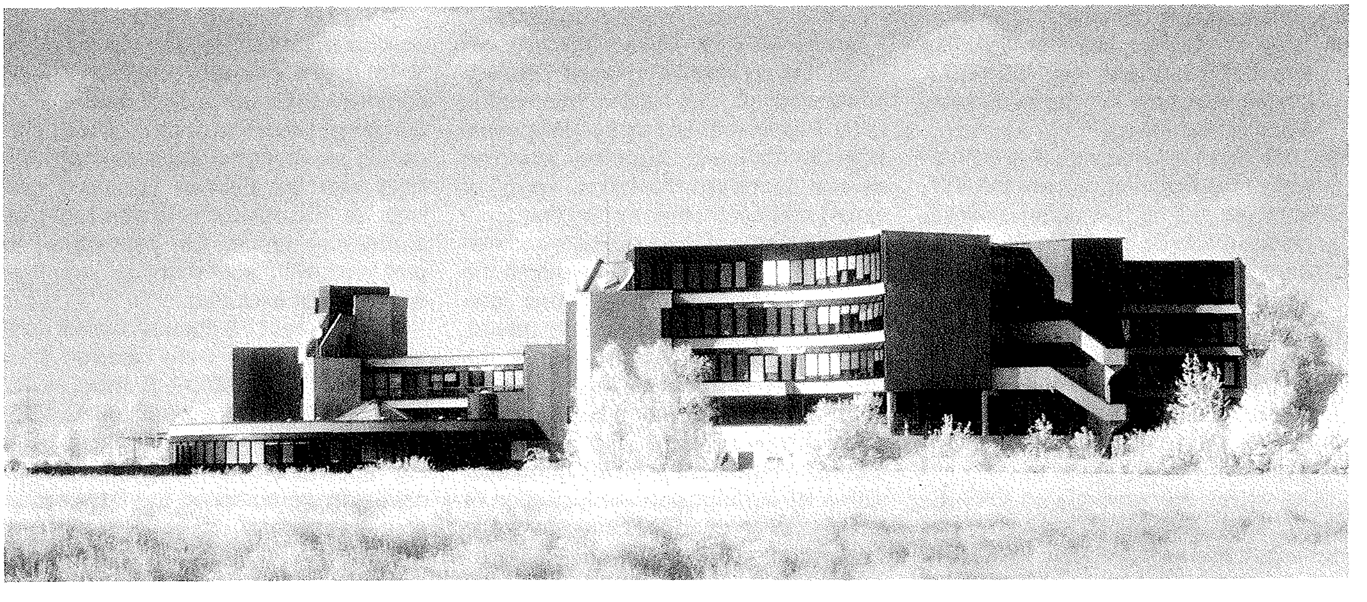
The Scientific Organizing Committee (co-chaired by M. J. Rees and G. Setti) has outlined the following programme:

Morning plenary lectures on:
Early Universe; Quantum Cosmology, High-Energy Physics – latest results; Nucleosynthesis; Galaxy Formation and High-z Objects; Large-Scale Structure; Dark Matter; X-ray and γ-ray Astronomy; Pulsars; Gravitational Lensing; Background Radiation; Solar Oscillations; Neutrinos and Underground Physics; Gravitation Theory.

Afternoon mini-symposia on:
Astrophysics of Neutron Stars and Black Holes (Organizer – R. D. Blandford)
Underground Physics (Co-organizers – B. Sadoulet and P. F. Smith)
Large-Scale Structure and Galaxy Formation (Organizer – G. Efstathiou)

The registration fee will be £ 75 (£ 25 for students). A first circular with a registration form has been circulated to institutes on the ESO mailing list. Information may be obtained from:

Professor L. Mestel
Chairman, Local Organizing Committee
Texas/ESO-CERN Symposium
Astronomy Centre
Division of Physics and Astronomy
University of Sussex
Falmer, Brighton BN1 9QH
ENGLAND



The New Look of the ESO Headquarters

Do you see something special on this photo? Yes, indeed, now the ESO Headquarters in Garching has a new fifth floor!

Photo made on a beautiful Bavarian spring day by ESO photographer H.-H. Heyer on Kodak High-Speed Infrared Film through an orange filter (f/8.5, 1/250 sec).

IAU WG on Photography To Meet at ESO

The IAU Working Group on Photography (of IAU Commission 9) will meet at the ESO Headquarters on October 29 and 30, 1990.

The topics will include: manufacture and behaviour of astronomical emulsions, photographic techniques (sensitometry, hypersensitization, calibration, conservation), applications (measurements and reduction, numerical techniques) and photography/CCD interaction. Although CCDs have taken over in many areas, photography is still of great importance for certain astronomical applications at many observatories, in particular in large-field survey-type work.

The scientific programme is being established by J.-L. Heudier and J. Schumann; they can be reached at Observatoire de la Côte d'Azur, B.P. 139, F-06003 Nice Cedex, France (EARN-email: WGAP@FRONI51). The local arrangements are made by the ESO Information Service (address on the last page).

STOP PRESS (June 6, 1990)

At Last, We Know Where La Silla Is!

Recent geodetic VLBI observations, the first involving South America, using the SEST telescope on La Silla, have successfully produced an exceedingly accurate position for the La Silla telescope. The observations performed by the Onsala/SEST group in collaboration with the NASA Crustal Dynamics project using SEST in VLBI mode with telescopes at Westford, Mass., Mojavi, Calif., and Onsala, Sweden, give a position solution for SEST as:

X = 1,838,239.55 m
Y = −5,258,700.06 m
Z = −3,100,588.47 m

in a geocentric coordinate system defined by the major VLBI telescopes. The distances between these telescopes have been determined with formal uncertainties, depending on the baseline length, between 6 and 23 mm, e.g. the distance from the Onsala 20-m telescope to SEST is:

10,459,732,492.4 mm (± 23.1 mm).

Note that this is only a first result and further processing, involving the full observing network of 8 telescopes, is in progress. *R. BOOTH, Onsala*

Vacancies

INFRARED ASTRONOMER

Education: University degree in Astronomy or Physics, preferably a doctorate.

Experience and knowledge: A solid background in observational infrared astronomy and a good working knowledge of infrared instrumentation.

Very good knowledge of English and a working knowledge of Spanish.

Assignment: As an international staff member in the La Silla Astronomy Department, the successful applicant will be expected to spend about half of his/her time doing original research and half doing support duties. The support duties include being Head of the IR Operations Group, introducing visiting astronomers to the use of IR instrumentation, and supervising the programmes of IR service observing. As Head of the IR Operations Group, he/she will supervise changeover routines of instrumentation, maintenance of instruments and detectors, development programmes in hardware and software, and, in general, will be responsible for monitoring the quality of the IR facilities offered by the Observatory.

Facilities: The observing facilities on La Silla comprise 14 telescopes including the SEST 15-m submillimetre antenna and the new 3.5-m NTT. Infrared facilities are available at 4 telescopes and include IR photometers, an intermediate-dispersion spectrograph (IRSPEC), and an imaging array camera (IRAC).

The research computing facilities on La Silla comprise a HP 1000 system with full image-processing capabilities (IHAP), a VAX 11/750 and several SUN workstations for image processing (MIDAS).

General information: Close to 20 astronomers, including staff members, fellows and students, work on La Silla. The research projects currently pursued by the astronomical staff at La Silla include low mass star formation (Herbig-Haro objects, molecular outflows, jets), OH/IR stars, symbiotic stars and proto-planetary nebulae, coronal activity in late-type stars, supernovae, chemistry of molecular clouds, formation of massive stars and starburst activitiy, dynamics of galaxies, active nuclei, QSOs and gravitational lensing, and observational cosmology.

Duty station: Astronomical Observatory, La Silla (600 km north of Santiago, Chile).

Starting date: As soon as possible.

Applications should be submitted to ESO Personnel Services at ESO-Garching before **July 31, 1990.**

FELLOWSHIP AT LA SILLA

A position is available at La Silla for a post-doctoral fellow with an interest in observational astronomy. Experience with IR spectroscopy, or optical photometry will be an advantage. ESO fellowships are granted for a period of one year, normally renewed for a second year and exceptionally renewed for a third and final year.

The successful applicant will be expected to spend not more than 50% of his/her time in support-related activities and the rest of the time doing scientific research.

Applicants normally should have a doctorate awarded in recent years. Applications should be submitted to ESO not later than July 31, 1990. Applicants will be notified by September 1990. 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 July 31, 1990.

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

European Southern Observatory
Fellowship Programme
Karl-Schwarzschild-Straße 2
D-8046 GARCHING b. München
Federal Republic of Germany

New ESO Preprints

(March–May 1990)

Scientific Preprints

697. L. Greggio and A. Renzini: Clues on the Hot Star Content and the UV Output of Elliptical Galaxies. *The Astrophysical Journal.*
698. Ph. Prugniel and F. Combes: Dynamical Friction in Pairs of Elliptical Galaxies. Ph. Prugniel and E. Davoust: Tidal Distortions in Pairs of Early-type Galaxies. Contributions to IAU Colloquium 124 "Paired and Interacting Galaxies", Tuscaloosa, December 4–7, 1989.
699. E. Gosset and J.-M. Vreux: On the Possible Biperiodicity of WR 40. *Astronomy and Astrophysics.*
700. L. Pasquini, E. Brocato and R. Pallavicini: Chromospheric Activity of Evolved Late-type Stars.
701. S. Cristiani et al.: Observations of Variable Quasar Candidates. *Monthly Notices of the Royal Astronomical Society.*
702. A.V. Sweigart, L. Greggio and A. Renzini: The Development of the Red-Giant Branch: II. Astrophysical Properties. *The Astrophysical Journal.*

703. E. Gosset et al.: Analysis of the Light Variations of the Wolf-Rayet Star WR 16. *Astronomy and Astrophysics Suppl. Ser.*
704. M. Morris and Bo Reipurth: The Optical Form of the Bipolar Preplanetary Nebula IRAS 09371+1212. *Publ. Astron. Soc. Pacific.*

Technical Preprints

13. A.F.M. Moorwood and B. Delabre: Infrared Spectrometer/Imager for the ESO VLT. To appear in Proceedings of SPIE Conference 1235 "Instrumentation in Astronomy VII".
14. J.M. Beckers et al.: The VLT Interferometer. I. Proposed Implementation. Paper presented at the SPIE Conference 1236 on "Advanced Technology Optical Telescopes IV" on February 12–16, 1990 in Tucson AZ, USA.
15. J.M. Beckers: The VLT Interferometer. II. Factors Affecting On-Axis Operation. Paper presented at the SPIE Conference 1236 on "Advanced Technology Optical Telescopes IV" on February 12–16 in Tucson AZ, USA.
16. J.M. Beckers: The VLT Interferometer. III. Factors Affecting Wide Field-of-View Operation. Paper presented at the SPIE Conference 1236 on "Advanced Technology Optical Telescopes IV" on February 12–16 in Tucson AZ, USA.
17. J.M. Beckers: The VLT Interferometer. IV. The Utility of Partial Adaptive Optics. Paper presented at the SPIE Conference 1236 on "Advanced Technology Optical Telescopes IV" on February 12–16, 1990 in Tucson AZ, USA.
18. M. Faucherre et al.: Michelson Versus Fizeau Type Beam Combination: Is There a Difference? To be published in the SPIE Proceedings vol. 1237 on "Amplitude and Intensity Spatial Interferometry", ed. J.B. Breckinridge.
19. F. Merkle et al.: First Diffraction-Limited Astronomical Images with Adaptive Optics. To be published in the SPIE Proceedings No. 1236.
20. P. Kern et al.: Adaptive Optics Prototype System for Infrared Astronomy. I: System Description. To be published in the Spie Proceedings No. 1271.
21. F. Merkle et al.: Adaptive Optics Prototype System for IR Astronomy. II: First Observing Results. To be published in the SPIE Proceedings No. 1271.
22. P. Dierickx et al.: ESO VLT II: Optical Specifications and Performance of Large Optics. To be published in SPIE Proceedings No. 1237.
23. P. Dierickx et al.: The 8.2 Metre Primary Mirrors of the VLT. To be published in the SPIE Proceedings No. 1271.
24. R.N. Wilson, F. Franza and L. Noethe: Active Optics IV: Set-up and Performance of the Optics of the ESO New Technology Telescope (NTT) in the Observatory. Submitted for publication in *Journal of Modern Optics.*

STAFF MOVEMENTS

Arrivals

Europe:

BALLESTER, Pascal (F), Science Applications Programmer
BERGER, Christian (D), Student
BRYNNEL, Joar (S), Electronics Engineer/Technician
COMIN, Mauro (I), System Programmer
GEHRING, Georg (D), Student
GOUIFFES, Christian (F), Fellow
GROESSL, Martin (A), VLT Project Engineer
HES, Roland (NL), Student
HILL, Susan (GB), Archive Operator
HUBIN, Norbert (F), Optical Engineer
KOCH, Franz (D), Structural Analysis Engineer
NIEUWENKAMP, Christine (NL), Adm. Asst. Purchasing
PIOTTO, Giampaolo (I), Associate
ZEILINGER, Werner (A), Fellow

Chile:

DELLA VALLE, Massimo (I), Fellow
EKMAN, Sture (S), Electro-Mechanical Engineer
HEINAUT-ROUELLE, M.-C. (B), Associate
WILD, Wolfgang (D), Fellow (SEST)

Departures

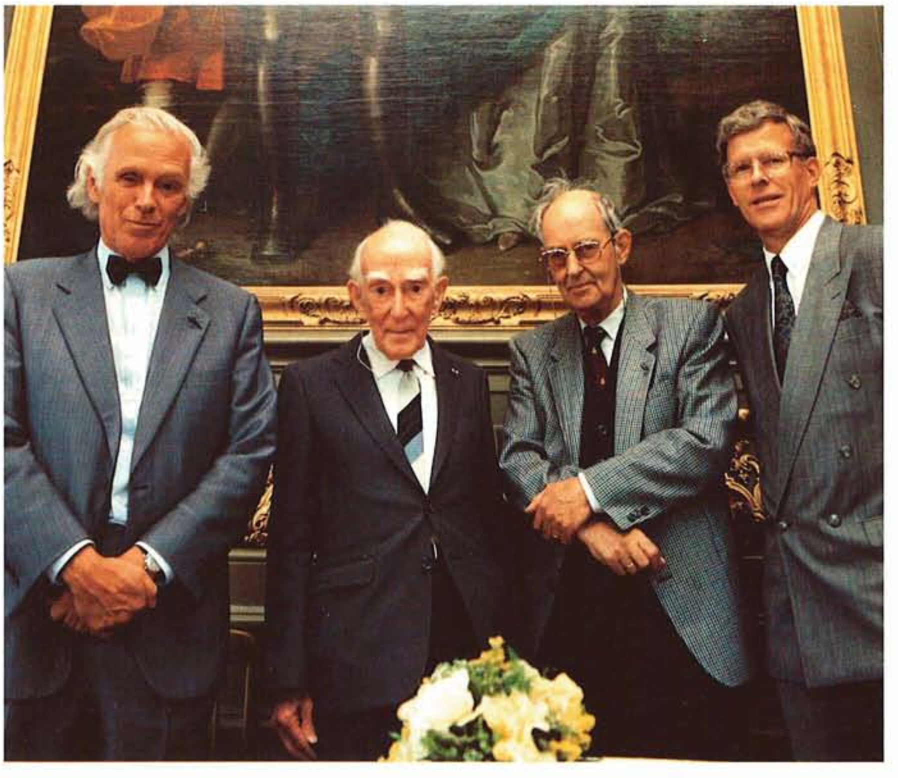
Europe:

GOSSET, Eric (B), Fellow
POSTEMA, Hans (NL), Mechanical Design Engineer
WENDORFF, Charles (DK), Associate
WOLTJER, Lodewijk (NL), Associate

Chile:

BAUDET, Loic (F), Optical Technician
GOUIFFES, Christian (F), Associate

Professor J.H. Oort at 90



Jan Hendrik Oort, one of the founding fathers of ESO, celebrated his 90th birthday on April 28, 1990. He was the President of the ESO Council from 1964 to 1965 and some of his many services to ESO and the world-wide astronomical community have been outlined in the articles by Adriaan Blaauw in the recent Messenger *issues.*

Professor Oort continues to take an interest in ESO affairs and was delighted to see the first results from the New Technology Telescope.

The photo shows Professor Oort flanked by Professors Blaauw (right) and Woltjer (left) and Professor van der Laan at the reception held in Leiden in honour of the famous Dutch astronomer on this festive occasion (Photo: Loek Zuyderduin).

ESO'S EARLY HISTORY, 1953–1975

VII. The Late 1960's: Structural Changes, First Scientific Activities and Some Soul-Searching; the Journal A & A*

A. BLAAUW, Kapteyn Laboratory, Groningen, the Netherlands

"La construction et l'installation du grand télescope – – – sont l'objet de sérieuses préoccupations de la part de la délégation – – –".

From a letter of the French Council delegates to the President of Council, June 15, 1969.

Introduction

The late 1960's were years of transition. With the dedication of La Silla in March 1969, ESO's first phase of constructions had been concluded. Realization of the Schmidt and the 3.6-m telescopes would be the main goals for the next years, besides the Observatory's taking up its functions as a research institute. The transition was accompanied by a change in the structure of the management of the Organization and by the creation of a Scientific Programmes Committee. While the latter, as one of its assignments, reflected on, and suggested, directives for ESO's long-range development beyond the Initial Programme of the Convention, the Organization also underwent some thorough – and sobering – soul-searching. These developments, together with a brief account on the first scientific activities and the role ESO played in the creation of the journal *Astronomy and Astrophysics* will be dealt with in the present article.

Changes in the Directorate

At the November 1966 Council meeting, Otto Heckmann reminded Council members that it was the present management's task "– – – to construct the Observatory, not to work scientifically – – –", and that his appointment as Director per November 1, 1962 had been for a term of five years, thus ending per November 1967; a decision would soon have to be taken on his future role. The Council meeting of June 1967 ensured Heckmann's continued supervision of construction activities by extending his appointment till the end of 1969, and responsibility for the development of scientific activity was assigned to myself in part-time association with the ESO Directorate. These moves were formalized by Council decisions of December 1967 at which also Ramberg's position was redefined: Heckmann became Director General until December 31, 1969; Ramberg Technical Director per January 1, 1968; and Blaauw Scientific Director on 50% time basis per February 1, 1968.

The new set-up functioned till Heckmann's retirement as Director General at which moment he was succeeded by the author. Ramberg continued as Technical Director (he would retire per December 31, 1971). The post of Scientific Director was suppressed per January 1, 1970. Heckmann continued for a limited period as consultant in connection with the work on the Schmidt and 3.6-m telescopes. Some other major appointments made about this time, connected with instrumental developments and administrative affairs will be mentioned later.

Meanwhile, Bengt E. Westerlund had per June 1, 1969 taken up the position of Director for Chile (based on Council's decision of June 1968) after having been associated with Steward Observatory in Tucson, Arizona, bringing to ESO his thorough acquaintance with the Southern Sky gathered during earlier association with Mount Stromlo Observatory in Australia. André Muller, after almost six years of building up ESO in Chile, returned to Europe where he joined the Office of the Director in Bergedorf per October 15, 1969 for the new task of organizing the rapidly growing Visiting Astronomers Programme. As we have seen in article IV, observational activity on La Silla had started at the end of 1966 with the 1-m telescope. It now grew rapidly.

Earliest Scientific Activities and the Creation of the SPC

About one year after the ratification of the ESO Convention, in its December 1964 meeting, Council appointed a small advisory committee for preparing a discussion on the way the Observatory should operate: on the size and role of permanent and semi-permanent staff, that of visiting astronomers, the allocation of observing time, etc. The group, consisting of A. Blaauw (Chairman), E. Geyer, A. van Hoof, P. Lacroute and B. Lindblad, met at Bergedorf on May 6, 1965 and submitted to Council a document "Considerations and Recommendations Concerning the Exploitation of the Observatory" [1]. As it reflected what at that time was expected from ESO, let me mention some of its contents.

It started by saying that *"Whereas the role of the observatory as an astronomical institute in its own right – – – should be of great importance, the facilities of the observatory should particularly be available to serve the national interests of the member states."* To this end, there should be a staff of permanent and semi-permanent members – to be engaged at the ESO establishments – and the facilities should be frequently used by visiting astronomers from the ESO countries. Besides the research by individual staff members and visiting astronomers, the observatory might conduct *"general programmes – – – to provide documents of fundamental significance but not necessarily requiring immediate analysis, such as, for instance, a sky-atlas, astrolabe programmes, systematic observations in Selected Areas, etc."* and these *"are the responsibility of the Council who, upon the recommendation of the Scientific Programmes Committee, may charge a staff member or, possibly, another astronomer with the supervision of such a programme."*

"Semi-permanent staff members – – – normally employed for about 3 years in Chile – – – should be well acquainted with the instruments and are to be charged with the instruction of the visiting astronomers in order to ensure efficient use of the observatory's facilities. – – – they [also] may be charged with the responsibility for the execution of the "general programmes". – – – At any time, there should be present in Chile and at the disposal of the Director, for each major ESO telescope a permanent or a semi-permanent staff member well acquainted with that telescope." With regard to semi-permanent staff the document stated that *"in order that ESO may attract qualified astronomers – – – it is necessary that they possess the guarantee of continuation of their positions in the home countries upon their return from Chile – – – continuation of pension rights and – – – social security benefits. It is of great im-*

* Previous articles in this series appeared in the *Messenger* Nos. 54 to 59.

By way of introduction to our description of the early observational activities on La Silla, we show the Observatory under the southern sky, as seen by the Chilean artist Nemesio Anthunesz. The painting was made at the request of the Swedish Natural Science Research Council – ESO being one of the many projects this Council supports – and it decorates this Council's Wenner-Gren Centre Headquarters in Stockholm. In 1970, when he made the painting, Anthunesz was Director of the Museo Nacional de Bellas Artes in Santiago.
In the artist's impression we recognize the general layout of the Observatory as seen from the south, with the Schmidt-Telescope building in the foreground and the cluster of intermediate-size telescope domes – and even the ENTEL Communications System relay mast – farther down. (Compare the photograph on page 31 of the previous article.) We also recognize, to the left above the Observatory, the conspicuous constellation of the Southern Cross with, starting from its extreme lower right star Alpha Crucis, in clock-wise order the stars Beta, Gamma, Delta and Epsilon Crucis. Naturally, as it is located at declination −60°, in reality the Southern Cross can be seen from La Silla only in southerly direction – but never mind . . .
The author is indebted to Dr. M. O. Ottosson, Council member for Sweden, who kindly made the photograph of the painting available for the Messenger.

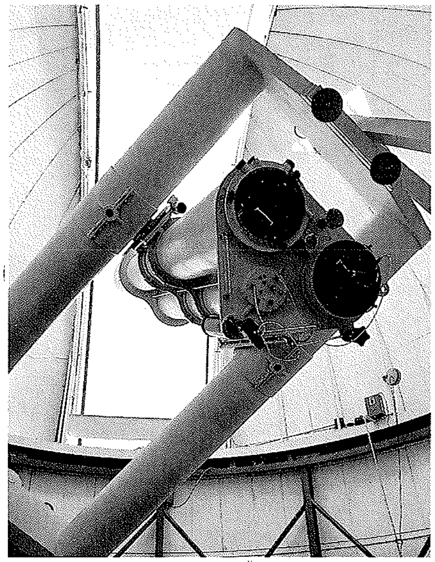
portance that the respective governments of the member states adopt a cooperative attitude towards this problem."

Visiting astronomers were supposed to stay in Chile for periods of two months to one year. The advisory group also proposed that Council establish two kinds of fellowships: those for young students, and those for distinguished scientists invited to do research at an ESO establishment. For the allocation of observing time the advisory committee suggested that applications by visiting astronomers were to be submitted first to national committees to be created for this purpose, who then would pass on the applications with their advice to a Scientific Programmes Committee – SPC – to be created by the Council. Proposals were added for the constitution and the task description of this SPC.

In several respects, the arrangements suggested were modified in actual practice. Not Council, but the ESO Director would be in charge of the execution of general programmes; short stays of visiting astronomers became the rule rather than the exception; applications were not first scrutinized by national commitees; special fellowships for distinguished astronomers would not be in order during the first decade; and guarantee for semi-permanent staff's continuation of their employment in the home country has seldom been granted.

The Scientific Programmes Committee (SPC)

In its meeting of June 1965, Council agreed with the suggestions of the advisory committee, and in December 1965 it appointed a working group (consisting of A. Blaauw, R. Cayrel and O. Heckmann) for making a more definite proposal for the task and constitution of the proposed Scientific Programmes Committee. The low priority which these matters still had at that time is reflected by the fact that only in October 1966 the group formulated its advice [2] for submission to the December 1966 Council meeting. This led to some revisions of June 1967 [3], following the Council meeting earlier that month. At that meeting, Council decided to establish a Scientific Programmes Committee, to be selected and appointed at the next Council meeting. Meanwhile, the advisory group dealt with the allocations for the 1-m telescope. The December 1967 Council meeting then appointed the SPC with B. Strömgren (Denmark) as Chairman, and the members J. Delhaye (France), E. Holmberg (Sweden), P. Swings (Belgium), G. Traving (Germany),



The Grand Prism Objectif (GPO)
After having served in South Africa in the context of site testing, the GPO was installed on La Silla where it resumed its work in the middle of 1968. The optical principle according to which the instrument operates has been described in article IV. The photograph shows the twin tubes of which the instrument consists: the left one carrying in front the specially designed objective prism, the right one serving for precise guiding during observing. Once installed at La Silla the GPO continued its work on the Magellanic Clouds, but now under much better atmospheric conditions than in South Africa.
From ESO Historical Photographs Archives.

studied in 1967 early-type stars in southern clusters and associations and carried out a test programme for a new infrared photometer, and guest observers J. Stock and E. Mendoza also used the telescope [5]. Observations were interrupted for a short period in the fall of 1968 when the telescope was moved from the provisional to its permanent dome.

The range of programmes broadened considerably in 1968 as is apparent from the lists of users given in the ESO Annual Report for that year. Apart from the continuing photometry of Magellanic Cloud stars by the Marseilles group, the majority of the observations were devoted to objects in the Galaxy. With the 1.5-m Spectrographic Telescope, in operation since the middle of 1968, after photographic tests with a provisional plateholder, work first concentrated on spectroscopy with the Chilicass Cassegrain spectrograph in which again work on the Magellanic Clouds dominated; it was performed by Dossin, Maurice and Prévot. Fr. Dossin, from Liège, had been associated with the Office of the Director in Bergedorf since February 1, 1966, but from February 1968 joined the staff in Chile. E. Maurice, of Marseilles, became a staff member in Chile from May 1968, after having been employed by ESO in Marseilles from January 1968 for work on the RV Cass spectrograph. L. Prévot of Marseilles Observatory had been engaged in the GPO programme in South Africa, as described in article II. In 1969 Cassegrain and Coudé spectrographic work was carried out in alternation. As reported earlier, the 61-cm Bochum and the 50-cm Danish telescopes came in regular operation in the course of 1969; for their programmes I refer to the lists in the ESO Annual Reports.

By the end of 1969, the astronomical staff in Chile consisted of the members mentioned already: Westerlund, Dossin, Schuster and Maurice, to whom had been added in the course of 1969 A. Ardeberg of Lund, from May 15, 1969, and J.J. Rickard, formerly of the California Institute of Technology, from October 1, 1969.

The First Coopérants

An interesting addition to the staff in Chile were French "coopérants". By agreement with the French Ministry of Foreign Affairs, in the context of French service to underdeveloped countries (specifically for Chile), young Frenchmen, preferably astronomy students, were allowed to substitute their military service for work on La Silla. For this service they were proposed by ESO to the Ministry, upon recommendation by the French National Committee for Astronomy. The first ones to enjoy this duty were Jacques Colin from Besançon Observatory who arrived in Chile early in 1970, and Jacques Breysacher from Nice Observatory, who followed in the fall [6]. From then on, each year French coopérants were stationed in Chile. Belgian coopérants soon joined them under a similar arrangement, but the other ESO member states could not be persuaded to interprete military service that scientifically.

The Roden Colloquium on Photometry of February 1966 and the Nice Colloquium on Spectroscopy of June 1969

The early photometric activities with the 1-m telescope had been inspired to some degree by ESO's first scientific colloquium, held under the title "ESO Colloquium on Photometry" at the Kapteyn Observatory at Roden from 9 to 11 February 1966. About 70 astronomers from the member states and some specialists from other countries attended, and reviewed the field of photoelectric photometry. An extensive report on the Colloquium was published by Borgman in *ESO Bulletin* No. 1 of November 1966 (which also gave two useful tables with the optical properties of the first ESO telescopes and spectrographs). For those who attended it is of interest to recall the quite unusual weather conditions prevailing at the start of the Colloquium: a sudden, heavy glazed frost causing breakdown of power lines and telephone connections, and thus for a while isolation of Roden Observatory and unheated lodging for some of the participants . . .

A spectroscopic counterpart to the Roden Colloquium was the ESO Colloquium on Spectroscopy, held at Nice Observatory on June 3–5, 1969. We are not aware of a comprehensive report; contributions were published separately, for instance one by A.B. Underhill on Early-Type Stars in *ESO Bulletin* No. 8, June 1971.

The Allocation of Observing Time

For allocating the observing time for 1968, the ESO Directorate called a meeting of the applicants, in its office, on November 23, 1967 [7]. Invitees were A. Ardeberg (Lund), A. Behr (Göttingen), M. de Vries (Roden), E. Geyer (Bonn) und U. Haug (Tübingen). The meeting acquainted the Directorate with the research interests in the member states, and made the applicants mutually acquainted with their projects. Such presentation of research proposals in the circle of fellow applicants was soon abandoned, however, when their number increased.

The SPC took over in the course of 1968. In July 1968 Council adopted rules for the allocation in accordance with a proposal of the SPC [8], the main elements of which were:
– Allocation was to be done for periods of 6 months: March–August and September–February; deadline for applications was six months before the beginning of the allocation period; per proposal the Directorate should request evaluation by at least one member of the SPC; final allocation was to be done by the Directorate at the recommendation of the SPC; for proposals of unusually long duration or heavy financial implication the Directorate should consult with the Chairman of the SPC; applicants were to be informed on the allocations at least four months before the beginning of the allocation period; but for all this, *"– – – rules to be handled with flexibility – – –".*

The SPC and the Future: More Telescopes and an ESO Centre?

From the outset, Council considered the SPC's task as twofold: not only should it advise the Directorate on the and Th. Walraven (Netherlands), and myself as secretary.

The appointment of Strömgren as Chairman deserves some comment. So far, his name did not occur in these articles except for his presence at the 1953 Groningen Symposium mentioned in article I. Bengt Strömgren, one of the most outstanding astronomers of our era, had left Denmark in 1951 after having been Director of Copenhagen Observatory since 1940, to become Director of Yerkes and McDonald Observatories, and was next, since 1957, connected with the Institute for Advanced Studies at Princeton. He returned to Copenhagen in 1967 [4]. Having always entertained a lively interest in ESO's development, Strömgren now was the obvious choice for the SPC Chairmanship.

The SPC held its first meeting on May 2, 1968 at the Bergedorf Office of the ESO Directorate. A list of the SPC meetings is given in the accompanying table. (It split by Council decision of June 1971 into the Observing Programmes Committee and the Scientific Policy Committee). Already at these first meetings, in 1968, important items of scientific policy were taken up apart from the evaluation of applications for observing time. However, before considering these, let me first review the scientific activities so far.

The last meeting of the Scientific Programmes Committee before it split into the Observing Programmes Committee and the Scientific Policy Committee was held at the Observatory at Roden near Groningen, on November 23, 1971. On this photograph (post-lunch at the restaurant), from left to right: Joke Westra (secretary of the Observatory), Eric Holmberg, André Muller, Martien de Vries (Roden Obs.), Bengt Westerlund, Paul Ledoux, Bengt Strömgren, the author, and Jan Borgman.
From ESO Historical Photographs Archives.

A variety of programmes had been conducted with the 1-m Photometric Telescope since its installation late 1966. Measures of the photometric extinction on La Silla were, of course, a first requirement. A major project was the photometry of stars in the Magellanic Clouds identified by means of the GPO during its operation in South Africa; this was done by J.P. Brunet of Marseilles Observatory. Observers from the Kapteyn Laboratory at Groningen

Meetings of the Scientific Programmes Committee, the Observing Programmes Committee and the Scientific Policy Committee* 1968–1974

SCIENTIFIC PROGRAMMES COMMITTEE (SPC)

Chairman: B. Strömgren

No.	*Date*	*Place*
1	1968 May 2	Bergedorf
2	1968 October 17	Bergedorf
3	1969 May 6	Copenhagen
4	1969 November 10	Marseilles
5	1970 April 29	Bonn
6	1970 November 11	Liège
7	1971 March 9	Geneva
8	1971 June 18	Paris
9	1971 November 23	Roden

OBSERVING PROGRAMMES COMMITTEE (OPC)

No.	*Date*	*Place*	*Chairman*
10	1972 June 13	Bergedorf	P. Swings
11	1972 December 15	Heidelberg	P. Ledoux
12	1973 May 24	Bergedorf	P. Ledoux
13	1973 December 11	Bergedorf	P. Ledoux
14	1974 June 17–18	Bergedorf	P. Ledoux
15	1974 December 2–3	Obs. Haute-Provence	P. Ledoux

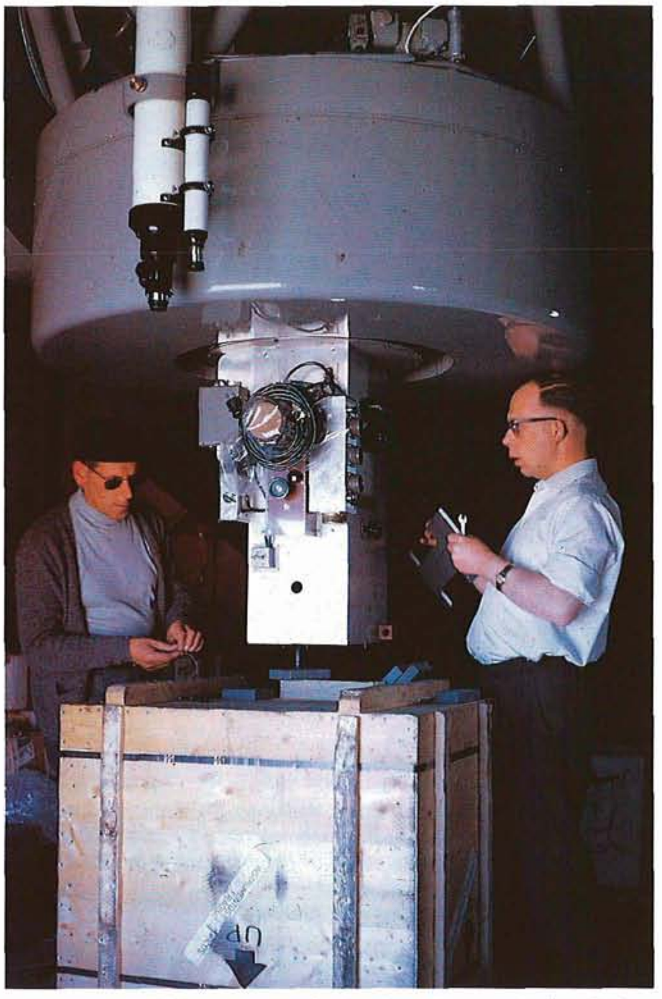
SCIENTIFIC POLICY COMMITTEE (SPC)

Chairman: B. Strömgren

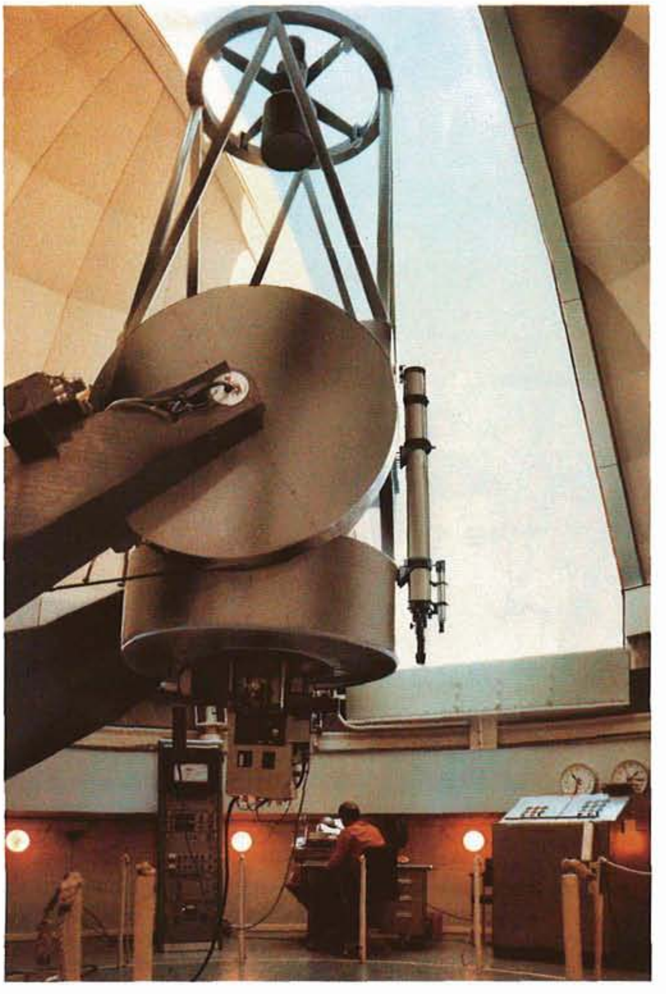
No.	*Date*	*Place*
1	1972 April 25	Copenhagen
2	1972 October 10	Bergedorf
3	1973 March 28	Paris
4	1973 September 14	Copenhagen
5	1973 November 7	Paris
6	1974 June 18	Bergedorf
8[1]	1974 September 3	Trieste
9	1974 December 4	Bergedorf

* By Council decision of June 9–10, 1971 the Sc. Progr. Comm. split into the Obs. Progr. Comm. and the Sc. Pol. Comm.; membership was appointed in the Cou meeting of Nov. 30/Dec. 1, 1971.

[1] In numbering the meetings of the SPC, the number 7 was erroneously skipped.



May 1967. The ESO photometer for the 1-m telescope, built at Roden Observatory, is mounted at this telescope by André Muller, left, and Martien de Vries of Roden Observatory. The 1-m telescope, the first one in regular operation on La Silla, at that time was still housed in its provisional dome and had earlier been used with a simpler, borrowed photometer.
Photograph from a slide by the author.



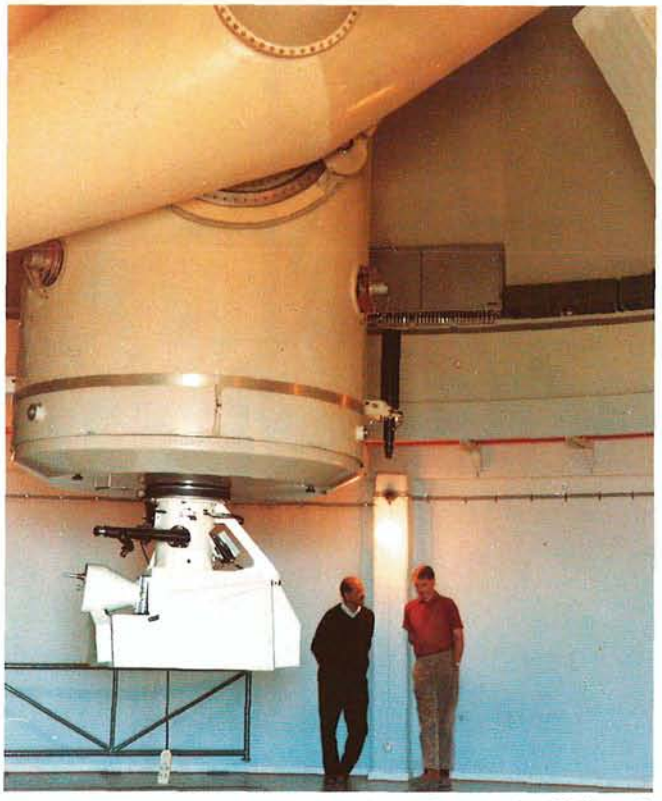
The 1-m Photometric Telescope
After having been housed in a provisional dome on La Silla since the end of 1966, the telescope resumed its work in the permanent dome in the fall of 1968. It is shown here after the move, equipped with the ESO Photometer and with Jan Doornenbal, ESO's Chief mechanic in the background. During the first years, the telescope was mainly used for the study of stars in the Magellanic Clouds detected by means of the GPO, and for individual stars, star clusters and stellar associations in our Galaxy.
From ESO Historical Photographs Archives.

allocation of telescope time, it also might suggest long-range research projects and extensions of ESO's observing facilities [9] beyond the "Initial Programme" of the Convention.

In their second meeting, on October 17, 1968, the SPC took up the thread of early Council deliberations of November 1966, in which Council had touched on the broadening of the ESO membership, on extension of its instrumentation, and on the possible creation, somewhere in Europe, of an ESO Centre for the development of measuring instruments and for promoting scientific contacts between astronomers of the member states. Reference was also made to the promotion of Laboratory Astrophysics, a new branch of astrophysics that rapidly gained attention in the mid-1960's [10]. The SPC now formulated more precise proposals and submitted these to Council in letters of the SPC chairman of November 15 and 20, 1968, for discussion in the Council meeting of December 3 and 4 [11]. We review here these proposals and the reactions in Council.

Strömgren's letter of November 20, discussed first by Council in the December 1968 meeting, emphasized that the Headquarters in Santiago should be well equipped with measuring facilities for visiting astronomers and resident staff, especially for the evaluation of photographic plates, but that such equipment should be developed preferably at an ESO Centre in Europe, in collaboration with both institutes in the member states and commercial firms, and this Centre should then also become a place for evaluation of observational data and a scientific meeting ground. As to Laboratory Astrophysics, shouldn't ESO take advantage of, and possibly support financially, capabilities for such work at institutes in the ESO countries?

Strömgren's letter of November 15, 1968, presented proposals for new, powerful telescopes; these had been supported meanwhile by the Instrumentation Committee on November 5 and 6 and concerned:
– a photometric telescope, intermediate in size between the 1-m and 3.6-m telescopes, for instance with an aperture of 2.0–2.5 m.
– a Schmidt telescope considerably larger than the ESO Schmidt at that time under construction, for instance one with aperture 2 m and focal length about 6 m.
– an astrometric telescope comparable to the one recently acquired by the US Naval Observatory.



The 1.52-m Telescope *equipped with the Cassegrain "Chilicass" spectrograph, borrowed from Marseilles Observatory. In the background, right, ESO's Chief-mechanic Jan Doornenbal talking to an (yet) unidentified person. In the early years, most of the observing time with the spectrograph was devoted to the determination of radial velocities and spectral types of stars in the Magellanic Clouds that had been detected by means of the GPO observations in South Africa.*
From ESO Historical Photographs Archives.

The 1.52-m Telescope, although designed primarily for spectroscopic observations, was also sometimes used for direct photography, especially in the early stage of optical tests. It is shown here equipped with the Zeiss camera.
From ESO Historical Photographs Archives.

The Proposed New Telescopes

For the photometric telescope the letter mentioned current research problems including: *"Wholesale photometry in the Magellanic Clouds of stars down the main sequence; photometry of faint variable stars like those of the Groningen-Palomar Survey; photometry in various globular clusters and in the directions of the galactic center and central bulge. – – – It would be unfortunate if work on problems of the type mentioned should have to be postponed until the time when the 3.6-m telescope is available. – – – it would certainly be desirable to work on the problems just mentioned with an intermediate-size telescope – – – with an aperture of 2–2.5 m – – – the SPC favors the Cassegrain type reflector with Ritchey-Chrétien optics, with an effective aperture ratio around 1 : 8. – – –"*

With regard to the Big Schmidt Telescope (the name used in Strömgren's letter) it stated: *"– – – it can be foreseen that the development of image amplification as well as photoelectric spectrum scanning with large numbers of channels, will make it possible to push limiting magnitudes in work with the ESO 3.6-m reflector – – – sufficiently far for the ESO 1-m Schmidt Telescope to become inadequate as a companion instrument for survey work. – – –"* Research problems considered by the SPC included general survey work on faint galaxies demanded by the expected flow of discoveries of radio sources, and many research programmes on galactic structure. *"– – – what members of the SPC had in mind in considering the possibilities of a big Schmidt Telescope was an aperture of approximately 2 m and a focal length of about 6 m."*

The proposed astrometric telescope was to aim at trigonometric parallaxes down to magnitudes 17 or 18, and at proper motions of high accuracy for the study of space motions out to distances of at least 500 parsec.

Highest priority was to be given to the photometric telescope, and to studies for the design of the Big Schmidt.

The above proposals were accompanied by the following cost estimates drawn up by Ramberg.

- Photometric telescope
  of 2–2.5 m .... $ 3,020,000.–
- Big Schmidt telescope
  of 2 m aperture ..... $ 6,240,000.–
- Astrometric telescope
  of 1.5 m aperture ... $ 3,200,000.–

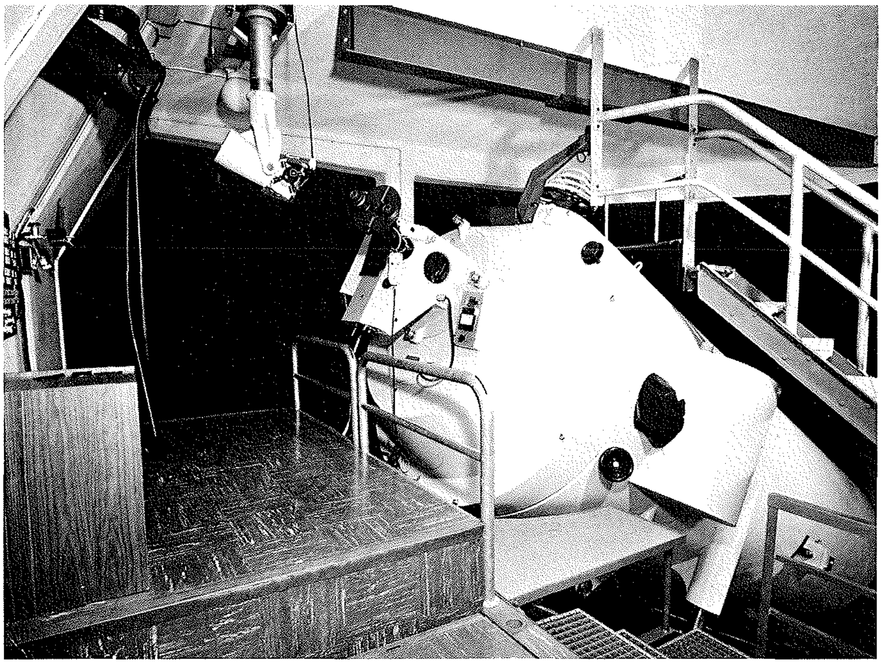
all of these including the building and dome.

The total amounted to . $12,460,000.–

For comparison: the total estimate of the 3.6-m telescope project as it occurs in an estimate of late 1969 compiled by Ramberg (to which we shall refer later) amounted to ..... $ 10,700,000.–.

In the discussions at the December 1968 and later Council meetings, the proposition of an ESO Centre in Europe for development of instrumentation and for the promotion of Laboratory Astrophysics struck a responsive chord because the wish for such a centre had been expressed earlier in Council. We shall later come back to this.

The proposals for additional telescopes were discussed at some length by Council in its meeting of December 1968. Soon after this, however, Council lost interest, for it became more and more clear that the ESO Directorate would have their hands full with the realization of the 3.6-m Telescope. Even



The Coudé Spectrograph
For observations requiring high spectroscopic resolution the 1.52-m telescope is used in combination with the Coudé spectrograph of which the upper part is shown in this photograph. It is mounted in fixed position below the observing floor of the telescope; the star light collected by the telescope is directed into the spectrograph by means of a set of mirrors of which the position adjusts itself during the motion of the telescope in such a way that the beam enters the instrument in constant direction. Work with the Coudé spectrograph started in the middle of 1969 and was concerned mainly with the study of interstellar lines and the determination of the abundances of elements in the atmospheres of the stars.
From ESO Historical Photographs Archives.

worse: concern about this realization soon overshadowed the optimistic views of the SPC about ESO's growth, and ESO was to undergo a short but sobering period of soul-searching. We do note, though, that the project of the Danish 1.5-m national telescope, realized later, would meet to a certain extent the desire for the proposed photometric telescope.

Soul-Searching in the Late 1960's

In article VI, when describing developments around the introduction of the national telescopes, I mentioned the concern, since late 1968, about the lack of progress in the completion of the Schmidt and large telescopes. Soon signals of discontent on these and some other points grew louder and the Council Meeting of March 1969 in Santiago appointed a Working Group to advise Council, under the Chairmanship of G.W. Funke (former President of the Council), and with the members K.F. Scheidemann (President of the Finance Committee) and A. Alline. Alline had just become the French government delegate on Council and was the one who most strongly voiced feelings of dissatisfaction. The Working Group's task was not strictly defined, but from the Council discussions it was clear that it should scrutinize many aspects of the functioning of the ESO Administration. These were to include: a confrontation of current activities with the aims as defined in the Convention, with special reference to such matters as the national telescopes and the new proposals by the SPC; the financial implications of such extensions; and certain aspects of the functioning of the administrative management.

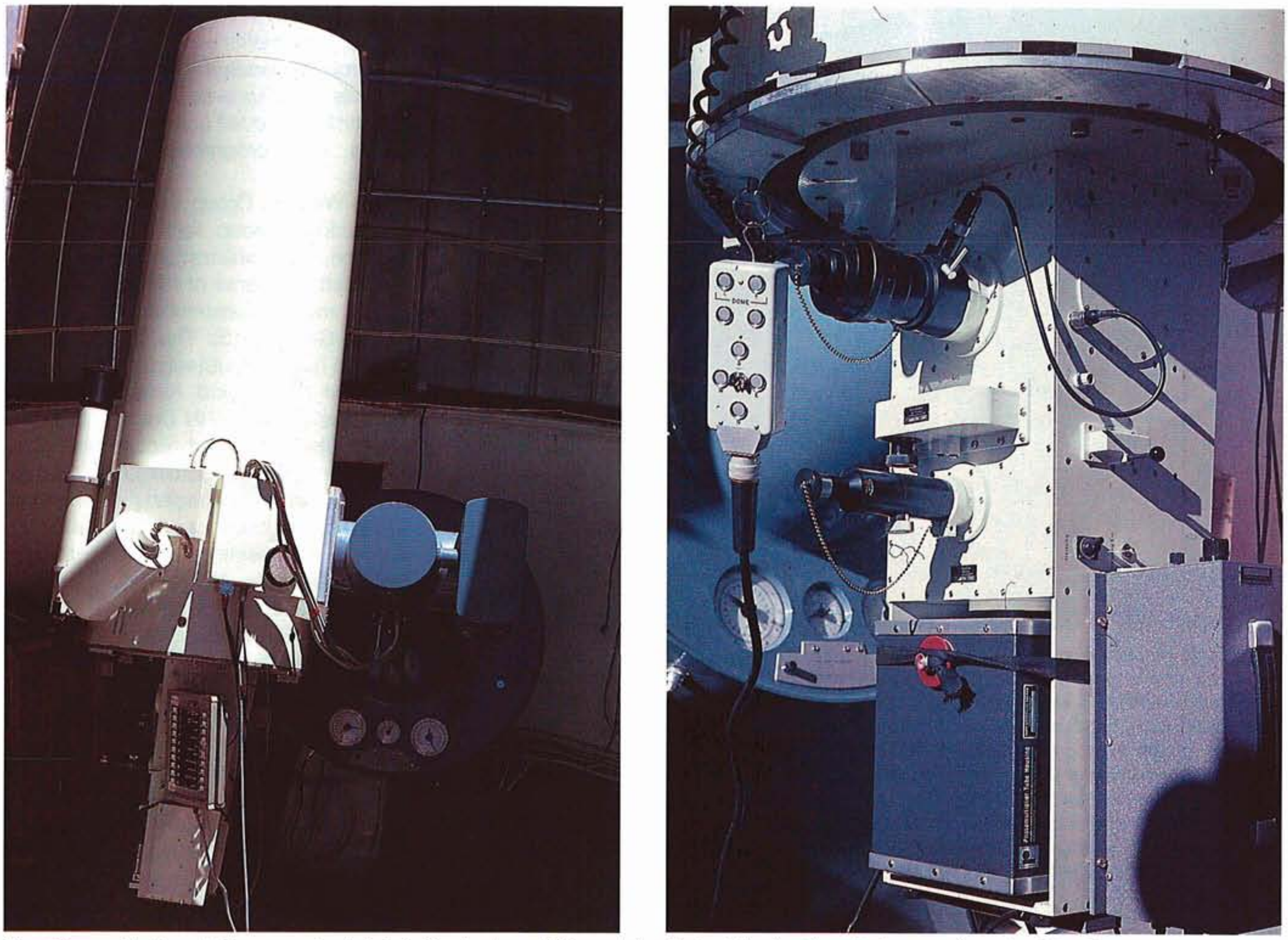
In a letter of June 15, 1969 to the President of the Council (Bannier), Alline, on behalf of the French delegation, elaborated more specifically, and critically, on these problems [12]: *"– – – La construction et l'installation du grand télescope – – – sont l'objet de sérieuses préoccupations de la part de la délégation française. – – – La délégation demande – – – que les provisions budgétaires – – – prennent pour objectif d'achever dans les meilleurs délais la réalisation du programme scientifique défini lors de la signature de la Convention [et] d'effectuer des économies sur les chapitres non directement liés à cet objectif – – –. L'installation et le fonctionnement d'instruments nationaux – – – n'est pas sans poser à cet égard d'importants et délicats problèmes. – – – Ni dans son esprit ni dans sa lettre la Convention n'autorise l'introduction de ces instruments – – –. La Convention n'interdit cependant pas l'introduction de ces instruments – – –. Il peut notamment être fait appel à cette fin à la notion de "programme supplémentaire – – –".*

The Working Group (referring to itself as Working Group for reviewing Programme, Administration Procedures and Staff Problems of the ESO Organization) met on September 11, 1969 at CERN, Geneva [13]. The choice of this location had undoubtedly to do with the fact that Funke and Alline both were members of the CERN Council. But in a way it also was symbolic: in his comments on the ESO Administration Alline had on several occasions referred to CERN procedures as an example. Invited for the meeting were also, for the ESO Directorate, Heckmann, Ramberg and the Manager Bloemkolk.

Main basis for the discussions was, after the definition of the Working Group's task, an extensive document prepared by the French delegation: "Mémorandum destiné à la discussion entre MM. Funke, Scheidemann et Alline, en vue de la rédaction du rapport demandé par le président du Conseil de l'ESO lors de la 12ème session de Conseil à Santiago, le 22 mars 1969" [14]. The French Memo dealt successively with the questions raised earlier: changes in the "Convention-size" of the telescopes; possible ways to speed up the work on the 3.6-m telescope; the structure of the ESO Management in Europe and Chile and the danger of too much dispersion in the latter, suggesting reduction of the "intermediate" stations La Serena and Pelícano between Santiago and La Silla; and the organization and presentation of financial and personnel matters.

The Report of the Working Group

The report of the Working Group was dealt with by Council at its meeting of December 15 and 16, 1969 [15]. The Group arranged its advice into four sections: The ESO Programme and the Convention; Budget Procedures; The 3.6-m Telescope; and Certain Other Questions. To the first, the Group observed that departures from the Convention with regard to specifications of the instruments so far had been "more from the letter than [from] the spirit of the Convention" and had not involved any appreciable rise in costs [16]. As to the question, which projects to consider as belonging to the regular programme, it recognized the occurrence of borderline cases and it referred to CERN's example of realizing a bubble chamber not foreseen originally as part of the



The 61-cm Bochum Telescope, *installed in September 1968, and the first of the "national telescopes" on La Silla. Financed by Bochum University and the Deutsche Forschungsgemeinschaft, it offered Bochum observers the outstanding observing conditions of La Silla whereas, for the logistic facilities offered by ESO, ESO observers received 30 % of the observing time. The telescope, manufactured by Boller & Chivens, was equipped with a photo-electric photometer made at the central workshop of Göttingen University.*

regular programme and including in its regular programme preliminary work for a storing ring project pertaining to the Supplementary Programme.

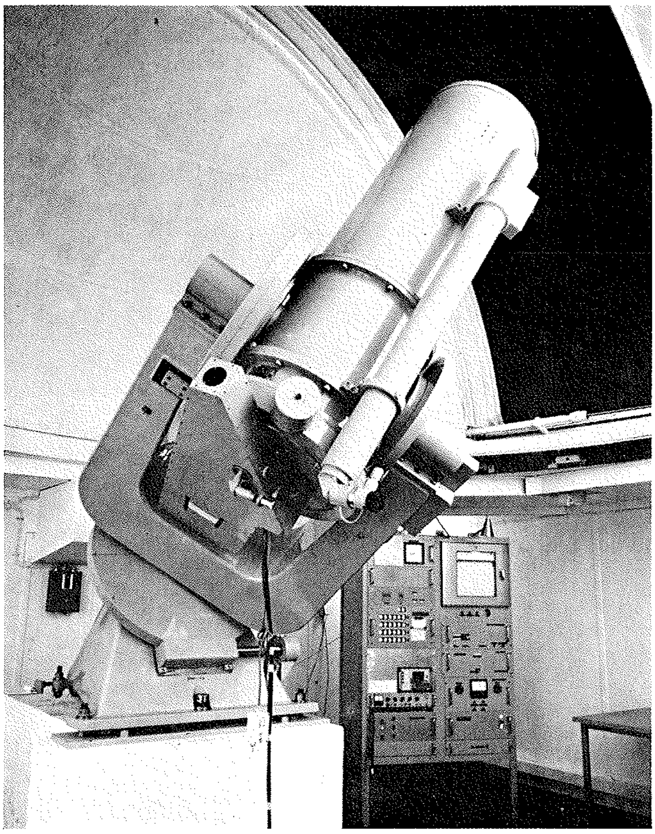
The Working Group recommended to Council *"a certain preparation for the continuous expansion"*, so as to enable it to consider carefully whether new projects should be included in the regular programme. With regard to national telescopes, the Group recognized that they *"can become a worthy addition to the ESO instruments"*, yet they *"--- would normally be allocated to the supplementary programme provision of --- the Convention or they would be wholly paid by the country concerned ---"* unless Council specifically incorporated them in the regular programme. With regard to budgetary procedures the Group recommended the adoption of a procedure similar to that used by CERN (see below). For the 3.6-m telescope project the Group recommended the preparation of a comprehensive status report and a detailed time- and cost schedule. Finally, the Group refrained from submitting any proposal concerning possible reduction of the dispersion of the facilities in Chile, and it suggested that Council reconsider its salary policy to make staff positions more attractive than they had been so far.

Judging from the minutes, the December 1969 Council Meeting took note of the report without extensive discussion. The meeting had a crowded agenda because of the succession in the General Directorate, and this did include as its principal item important reports concerning the 3.6-m Telescope Project which we will encounter later. Yet, there are several items in the memo and the Report which have distinctly left their mark on later developments in ESO and therefore are worth pointing out here.

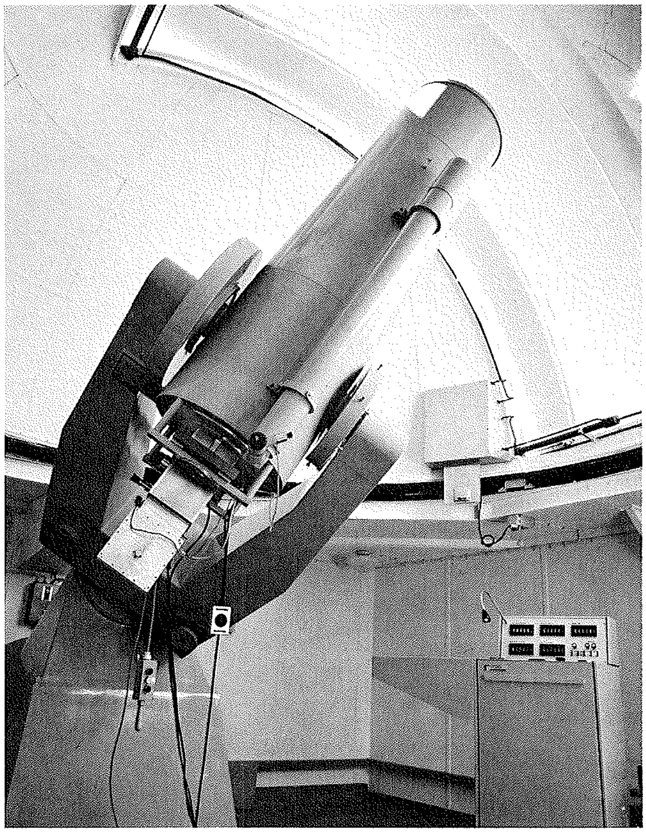
First of all, this soul-searching had a sobering effect on the over-optimistic suggestions made by the SPC for extensions of the ESO facilities. However, Council appeared to remain receptive to the idea of the creation of an ESO Centre in Europe, where *"the most sophisticated equipment for evaluation should be located, astronomers from the ESO countries could work together and also, in collaboration, new instruments could be developed ---"*. To some extent, these wishes would be satisfied by the TP-Division created early in the 1970's.

With regard to financial and personnel matters, dissatisfaction among some Council delegates stemmed mostly from two causes: a lack of stability in the budget requirements, and lack of transparency in the documentation for Finance Committee and Council. The latter was not difficult to understand in view of the fact that the ESO Management had to set up an organization of unprecedented nature and size in astronomy, whereas most of the members of Council and FC were accustomed to streamlined procedures in well-established organizations.

For improving the situation, as a natural example Council tended to look at procedures established at CERN with its ten years longer experience (CERN was created in 1952). An important result was the introduction, in the early 1970's, of the so-called Bannier proce-



The Copenhagen 50-cm Telescope, *the second of the "national telescopes", shortly after it had been installed in its permanent dome in the middle of the year 1971. When it arrived on La Silla early in 1969 it was first mounted in the dome that had served earlier for the ESO 1-m telescope. The photograph shows it with the Copenhagen 4-channel photometer designed for photometry in the so-called Strömgren narrow-band system.*



The ESO 50-cm Telescope *shortly after its installation in late 1971. The telescope is a duplicate of the Copenhagen 50-cm telescope and was, like the latter, manufactured at Copenhagen. It was acquired by ESO in the context of developments for the control system of the 3.6-m Telescope so that these could first be tried out in actual practice on a small instrument. Initially, as in the above photograph, it was equipped with a one-channel photometer. Like the two 50-cm telescopes, their domes also are twins.*

dure adopted by CERN for budget planning; I expect to return to this later when reviewing financial and personnel developments. In order to avoid misunderstandings it should also be recorded here, that the report of the Working Group explicitely stated that "– – – *Management [essentially consisting of the Manager J.H. Bloemkolk and his staff] has accomplished its work in commendable fashion – – –*".

Creation of Committee of Council

Finally, we note that at the March 1969 Council Meeting in Santiago the suggestion was made, by Alline, that ESO follow CERN's example by having a "Committee of Council" for the purpose of discussing in an informal manner, in between Council meetings and with restricted participation, those items which might give rise to controversies between the Council delegations mutually, or with the Directorate – and thus pave the way for smooth Council proceedings. A Committee of Council was established at the December 1969 meeting [17] and did function from the middle of 1970; it will figure in the list of Council meetings in a later article.

ESO and the Creation of the Journal *Astronomy and Astrophysics*

It seems appropriate to devote in the present context a few paragraphs to the role ESO played in the year 1968 in the creation of the journal *A & A* which since then has become one of the leading astronomical journals, and still has an administrative link to ESO. Its creation, too, was one of the steps in the process of Europeanization of scientific activity. The close tie between the Journal and ESO, reported below, has led to the incorporation of the documentation related to the Chairmanship of the Board of Directors of the Journal over the first ten years of its existence, into the ESO Historical Archives. Accordingly, reference is made to these archives [18]; helpful has also been an earlier account by the author on the creation of the Journal [19].

On April 8, 1968 some leading astronomers from Belgium, Denmark, France, the Federal Republic of Ger-

(Continued on page 34)

Centrefold

Giant clouds of molecules and infrared sources are invariably linked to star-forming regions.

The complex star-forming region NGC 3576 is located near the plane of our galaxy, at a distance of about 3.6 kpc. Associated with this nebula lies a giant molecular cloud of mass $\sim 10^5 M_\odot$. *A cluster of 5 infrared sources have been reported. Approximately seven early-type (young) stars would be needed to ionize the entire observed region, some 10 arcminutes in extent.*

Spectacular arcs and streaming motions can be seen in this colour-composite, made from three black-and-white Schmidt plates, secured by David Block at La Silla earlier this year. The blue (IIIa-J) and red (IIIa-F) plates were hypersensitized in nitrogen and forming gas and exposed for 60 min and 120 min, respectively through GG 385 and GG 495 filters. The green (103a-D) plate was exposed for 60 min with a GG 495 filter to approximate the V ("visual") waveband.

The composite was made by Claus Madsen and reveals important temperature gradations, from the red to the ionized pink-white central area.

D. BLOCK, *ESO and University of Witwatersrand, South Africa*

many and the Netherlands met at Leiden to prepare a possible merging of some of the principal astronomical journals that appeared in Europe [20]. The meeting had been convened by S.R. Pottasch of the Kapteyn Laboratory who, together with A. Reiz of Copenhagen Observatory and J.-L. Steinberg of Meudon Observatory had been the first to explore attitudes with regard to a possible merger; Pottasch and Steinberg were closely connected with editorial work for a journal in their countries. The idea found general support and nine months later, per January 1, 1969, the first issue of the new journal appeared. The merging journals were: *Annales d'Astrophysique* (founded in 1938), *Bulletin Astronomique* (1884), *Journal des Observateurs* (1915), *Zeitschrift für Astrophysik* (1930), and *Bulletin of the Astronomical Institutes of the Netherlands* (1921), to which was added later the Scandinavian *Arkiv för Astronomi* (1948). First editors of the new journal were S.R. Pottasch and J.-L. Steinberg. The related series *A & A Supplements* appeared one year later, per January 1, 1970 under the editorship of L.L.E. Braes of Leiden, who was succeeded in 1971 by B. Hauck of Lausanne. The *Monthly Notices of the Royal Astronomical Society* refrained from merging, by decision of the Council of the Society on October 13, 1967 [21].

How did ESO come in? The April 1968 meeting had resolved that the affairs of the Journal should be supervised by a Board of Directors consisting of astronomers and representatives of sponsoring national organizations. This Board should be the autonomous owner of the Journal, including the title, with a private publisher acting as agent for the Board. However, in order to enter into a contract with the publishing agent as well as for other reasons, a legal status for the Board would have been required, the accomplishment of which for an international organization would have been a time-consuming and somewhat complicated affair. An alternative solution was therefore preferred: making use of the legal status of ESO, whose aims as a joint European astronomical programme ran parallel to those of the Journal. The matter met support by the ESO Council in July 1968, so that steps could be taken to prepare the necessary legal documents. These found final approval and confirmation at the December 1968 Council Meeting [22]. They were:

– a statement concerning the creation of the Journal and the relation of its board of Directors to ESO;

– a formal agreement between ESO and the Board of Directors;

– the contract between ESO and the publisher, Springer Verlag;

and accordingly Council authorized the Director General of ESO to sign the contract just mentioned.

The basic idea was, that ESO would make its administrative and legal services available to the Board of the Journal but would carry no financial obligation or responsibility. Apart from making use of ESO's services, the Board would have an entirely independent status excluding influence from ESO side on its scientific policy. As a trait-d'union between ESO and the Board, the author, at that time Scientific Director of ESO, became a member of the Board of Directors – and was, in fact, chosen as its Chairman.

Henceforth, European astronomers would turn to the new Journal for the publication of their work – including that based on observations at La Silla.

References and Notes

Abbreviations used:

EHA = ESO Historical Archives (see *The Messenger* of December 1988).

FHA = Files Head of Administration at ESO Headquarters.

EHPA = ESO Historical Photographs Archives.

[1] FHA Doc. ScAct-1.
[2] FHA Doc. ScAct-2.
[3] FHA Coc. ScAct-3.
[4] For a short biography of B. Strömgren see, for instance, the obituary by M. Rudkjöbing in *Quarterly Journal R.A.S.* Vol. 29, p. 282, 1988.
[5] See the report by Blaauw in *ESO Bulletin* No. 4 of July 1968.
[6] See Minutes Cou Meeting, June 1970, p. 41.
[7] See FHA Docs ScAct-4 and 5.
[8] FHA Doc. ScAct-6.
[9] See FHA Doc. ScAct-3 of June 1967.
[10] Minutes 7th Cou Meeting, p. 29ff.
[11] Strömgren's letter of Nov. 15 with accompanying Cou Letter 00/2426/68 of Ramberg, and Strömgren's letter of Nov. 20 with accompanying Cou Letter 00/2464/68 by Manager Bloemkolk, both in FHA Cou and FC Doc's 1.1.1./ 1.2.1., Circular Letters.
[12] Letter marked 3137/69 in file FHA 1.1.1/ 1.2.1.
[13] FHA Doc. Cou-2, 2283/69.
[14] In FHA, attached to the Report of the Working Group referred to under reference [14].; an English translation was made at the request of Funke according to FHA 1.11/1.21, Cou-2 2321/69.
[15] FHA Doc. Cou-2 3304/69.
[16] We note that in the W. Group's report the GPO is not considered as one of the three middle-size telescopes of the Convention, contrary to the decision taken by the ESO Committee in July 1960 as reported in article IV.
[17] See, for instance, FHA Doc. Cou-2 3309/69.
[18] EHA-I.C.7.; not yet subclassified in December 1989.
[19] In Europhysics News, *Bull. of the Eur. Phys. Soc.*, Vol. 6, No. 12, Dec. 1975, p. 3–5.
[20] A report on this meeting by S.R. Pottasch is in the section Earliest Developments of the Archives.
[21] The Archives contain the relevant correspondence of D.H. Sadler and F. Graham Smith with J.H. Oort and S.R. Pottasch of October 1967, and the report of the R.A.S. Working Group for study of the matter.
[22] See minutes of this meeting and Doc. FHA Cou-2 CL 2399 of Nov. 14, 1968.

SN 1990 I in the Polar Ring Galaxy NGC 4650 A

L. PASQUINI, ESO

1. A Brief History

On the night of April 29/30, 1990, Oscar Pizarro, night observer assistant at the ESO Schmidt telescope found on an ESO Schmidt B plate taken on 27.1 April 1990, a new, rather luminous object, situated very close to the edge of a quite bright galaxy. The discovery was made by comparing the new plate with an old one taken about 10 years ago. From a first glance at the plate, it was clear that the object was likely to be a new supernova.

The host galaxy turned out to be NGC 4650 A ($\alpha = 12^h 42^m 05^s$, $\delta = -40° 26' 30''$, 1950 Equinox) with the object located 14 arcsec east and 47 arcsec south of the galaxy nucleus. Before the end of the same night we managed to obtain 2 CCD frames (B and V filters) at the ESO-MPI 2.2-m telescope. Although the observations were performed at a very high airmass (~ 2), we succeeded in obtaining quite accurate photometry; the mean values were (29.4 April 1990) V = 15.6 and B = 16.7. Due to the location of the object and to its brightness

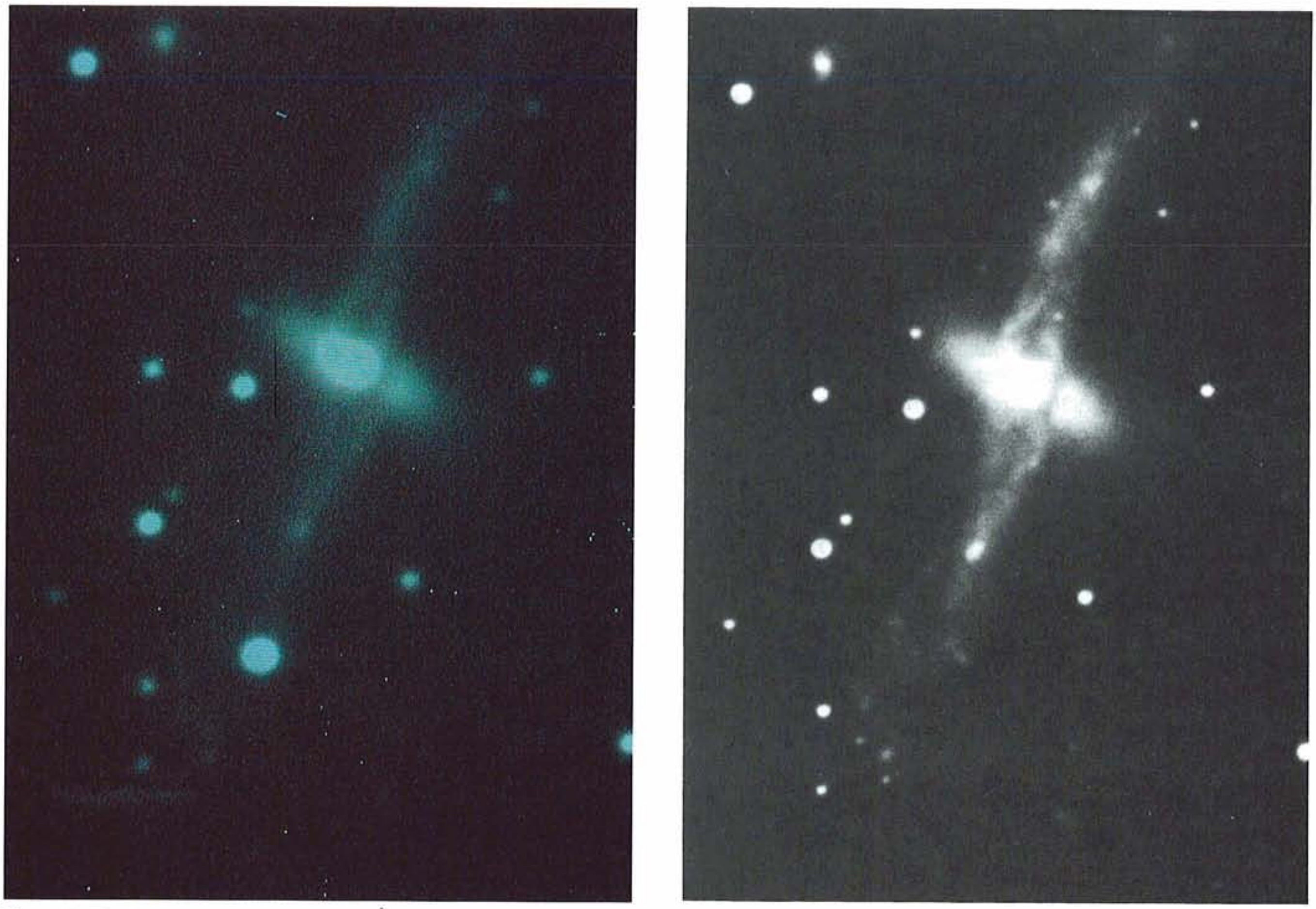


Figure 1: *The left picture shows a 2.2-m CCD exposure of SN 1990I in NGC 4650A in the V band. The SN is the bright object, close to the southern end of the polar ring. It is absent on the picture to the right which has been reproduced from a 90-minute exposure, obtained in 1977 with the ESO 3.6-m telescope on IIIa-J emulsion. North is up and east is to the left.*

(see Fig. 1) we were confident that we were dealing with a new supernova (Pizarro et al., 1990).

In order to learn the type of this SN, a 30-min. spectrum was obtained the following night (April 30.1) at the ESO 1.52-m telescope equipped with the Boller and Chivens spectrograph attached. The spectrum, flat field corrected and sky subtracted, is shown in Figure 2. By comparing the prominent features between 5400 and 6800 Å with published SN spectra (e.g. Branch et al. 1983) and considering the observed colour index and the absolute magnitude of the SN (Heliocentric velocity of NGC 4650 A = 2904 km sec^{-1}, Whitmore et al., 1987), it appears that SN 1990 I is a supernova of type Ia, ~40 days after the maximum (Pasquini, Jarvis and Leibundgut, 1990).

A careful analysis of published data on type Ib supernovae (Harkness et al., 1987), however, shows that spectra and colours of a Ib supernova ~20 days after maximum can be almost identical to those of a SN Ia which is only few weeks older; we cannot then exclude that SN 1990 I is a Ib SN 2–3 weeks after maximum. For the time being it is not possible to distinguish between these two possibilities by means of optical observations, but the differences between type Ia's and Ib's should be clear ~200 days after maximum. In fact, at that stage, while Ia spectra are dominated by FeII and FeIII lines (Meyerott, 1980, Danziger et al., 1990), Ib supernovae show prominent OI lines (Gaskell et al., 1986).

2. SN 1990 I and the Host Galaxy

NGC 4650A is probably one of the best studied polar ring galaxies (Laust-

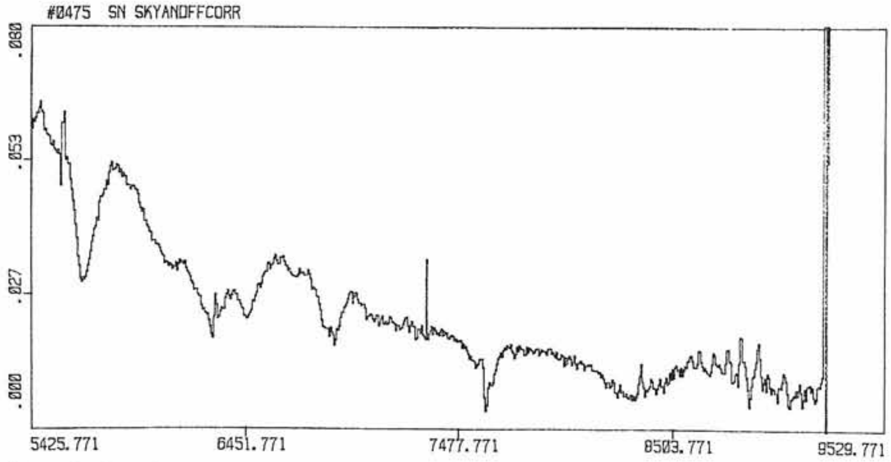


Figure 2: *30-minute Boller and Chivens spectrum of SN 1990I taken at the ESO 1.5-m telescope. The spectrum, wavelength calibrated, is corrected for flat field and sky subtracted.*

sen and West, 1980, Whitmore et al., 1987); in Figure 1 the ring is visible as a disk-like feature almost oriented north-south and SN 1990I is located close to its southern edge. Although it cannot be exluded that the alignment of the SN 1990I with the polar ring is a projection effect, it is more probable that the SN was really formed in the ring.

The possibility that SN 1990I is of type Ia and is associated with the ring, makes this object particularly interesting, because the ring has quite blue colours, is knotty and very rich in HII regions indicating significant recent star formation (Laustsen and West, 1980); on the other hand, SN type Ia are typical of galaxies in which no young stellar population is present and it is generally agreed that Ia supernovae are associated with a low mass, old population (Woosley et al., 1986).

The location of SN 1990I would not be unusual if, instead, we were dealing with a type Ib, which are thought to have massive progenitors. Since the number of spectroscopically and photometrically well-sampled supernovae Ib is rather small, the follow-up of SN 1990I is very interesting, even if it should turn out not to be of type Ia.

The favourable location of SN 1990I in the sky will allow La Silla observers to follow it during the next 5 months or so.

Acknowledgements

Special thanks and congratulations go to O. Pizarro, who discovered SN 1990I in his long-term survey of Schmidt plates. I also appreciate the help of M. Bahamondes, J. Miranda and J. Borquez in obtaining some of the early observations, as well as several visiting astronomers, who kindly spent part of their time observing SN 1990I: V. Burwitz, D. Pollacco and J.P. Sivan. Finally, I am grateful to B. Leibundgut and E. Oliva for helpful discussions.

Latest News

According to M.M. Phillips, CTIO, spectra of SN 1990I show that it is of type Ib (IAUC 5032; June 14, 1990).

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The Stellar Content of the Dwarf Galaxy NGC 3109

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1. Introduction

Despite their modest appearance, dwarf irregular galaxies (DIGs) form an interesting class of objects in many respects. First, the high mass-to-light ratios measured for the smallest systems make DIGs some of the best candidates for the study of the dark matter content of the universe. Observations suggest that the ratio of hidden-to-luminous matter increases when going from irregular systems such as Sextans

Figure 1: *The SBm galaxy NGC 3109 from an ESO 3.6-m 60-min exposure on Kodak IIIa-J + GG 385.*

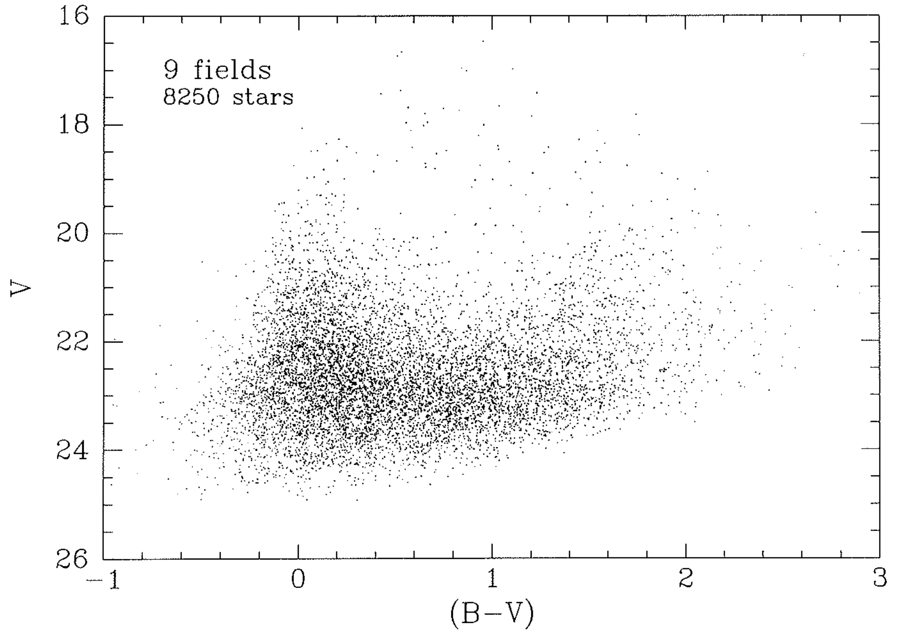

Figure 2: *C-M diagram of the stars projecting on the 21′ × 3′ region centred on NGC 3109, not corrected for field star contamination.*

A and LGS 3 towards the smaller dwarf spheroidals Ursa Minor and Draco (cf. Trimble 1987).

Second, since DIGs are generally believed to be simple and rather unevolved objects, they are excellent laboratories to study the early phases of the chemical evolution of galaxies. Spectrophotometric investigations have revealed that the metal content is generally low, ranging from approximately a few hundredths to half of the solar value. The low metallicity is of consequence in cosmology, since it favours the estimate of the primordial abundance of Helium, a figure of paramount importance in testing the Big Bang theory. Furthermore, DIGs are probably the most common galaxies in the universe; this too can be of cosmological interest in that it bears on the theories of galaxy formation as well as on the estimate of the total mass of the universe.

Third, DIGs play some role in the problem of the cosmic distance scale: Cepheid variables have been identified in the nearest galaxies, and used to estimate their distance moduli. These measurements have led to the extension of the faint end of the relation between luminosity of the brightest blue and red supergiants and absolute magnitude of the parent galaxy (Humphreys, 1983). Such a calibration is of great importance for the determination of distances to more distant galaxies in which Cepheids can no longer be seen.

Finally, given their structural simplicity (e.g. lack of spiral arms), DIGs are better places than the more complex and larger spirals, to study star formation processes. Such processes can be spectacular in dwarf irregulars, especially in the blue compact galaxies. The intense activity relatively to the small sizes of these galaxies accounts for their blue colours and for the presence of several associations of young stars; the latter are often embedded in large clouds of ionized hydrogen, and give these galaxies their clumpy and knotty appearance. The availability of great reservoirs of gas supports the belief that dwarf irregulars are young and still relatively unevolved galaxies with regard to star formation. The question of whether star formation is a continuous process or rather a sequence of single bursts, is still controversial. The burst model is usually preferred in interpreting the properties of the blue compact galaxies, while more normal DIGs are thought to experience a continuous and constant activity (Hunter and Gallagher, 1985).

More than a dozen DIGs have already been identified in the neighbourhood of the Galaxy, and so close that their stellar content is quite well resolved. The availability of software packages allowing photometry in crowded fields, such as DAOPHOT or ROMAFOT, has permitted the construction of C-M diagrams for a certain number of these objects (Table 1). Combined with stellar evolution models, these measurements have shed some light on the characteristics of the stellar populations of the nearest galaxies, showing similarities in their content of massive stars, as well as in the shape of the Initial Mass Function.

We have recently undertaken a systematic programme for the study of the stellar populations in some nearby DIGs through multicolour CCD photometry. Material has already been collected for UKS 2323, IC 1613, and NGC 3109, and a first account of the results obtained for UKS 2323 has been given by Capaccioli et al. (1987). Here we present some new results concerning a classical photometric target, NGC 3109.

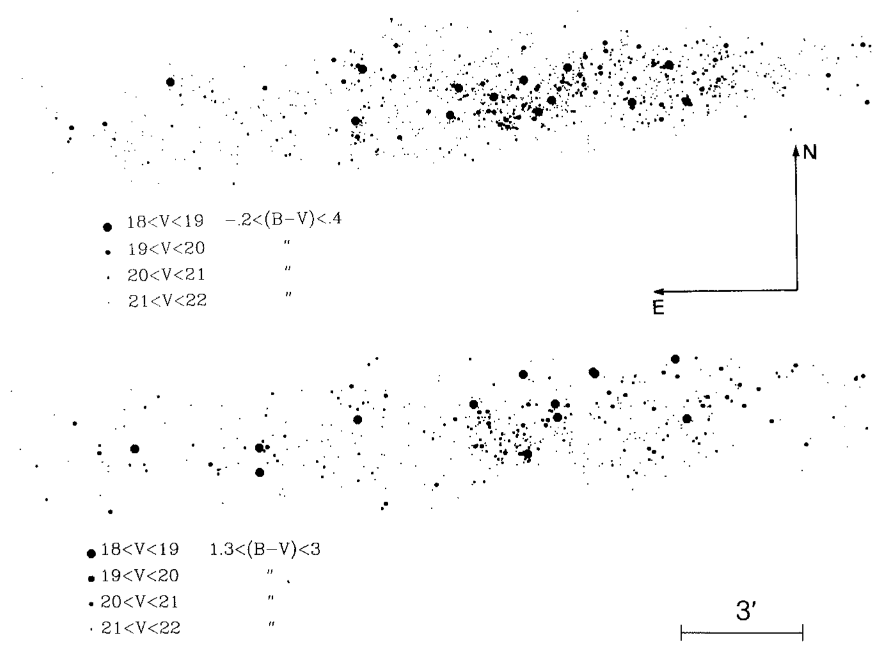

Figure 3: ***Upper panel:*** *projected distribution of the brightest blue stars of NGC 3109 contained in the diagram of Figure 2; the central bar and the two eastern spiral arms are discernible.* ***Lower panel:*** *map of the brightest red stars.*

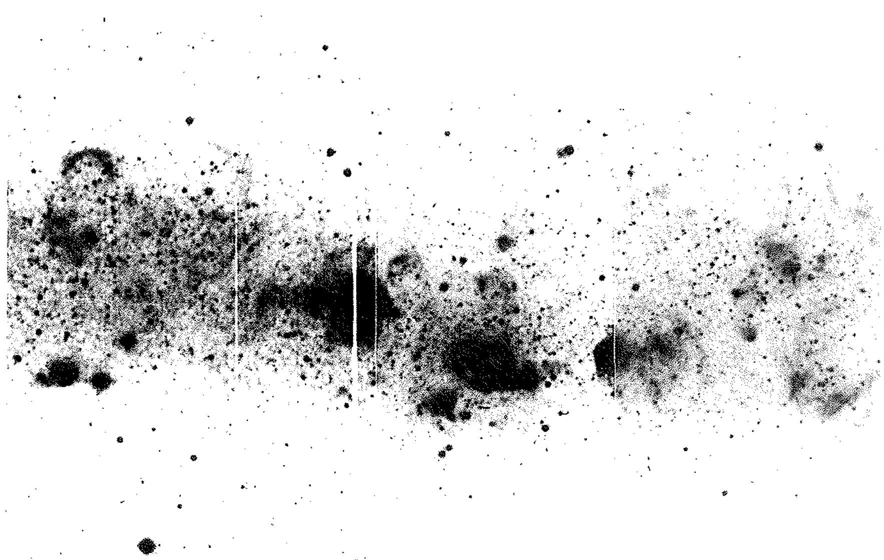

Figure 4: *Mosaic of three CCD frames of NGC 3109, centred on the west end of the bar and taken through an Hα filter.*

2. NGC 3109: Observations and Data Reduction

NGC 3109 = DDO 236 (Fig. 1) is a magellanic spiral located at the periphery of the Local Group: its distance modulus, based on Cepheids, is $(m\text{-}M)_B \simeq 26$ according to Sandage and Carlson (1988; hereafter referred to as SC). While comparable to the Small Magellanic Cloud from the point of view of luminosity ($M_B = -16$), the size of NGC 3109 makes it one of the largest magellanic systems known so far (D = 14 kpc, corresponding to 0°.5 on the sky). Previous studies of its stellar content are by Demers et al. (1985) and by SC; both of them are based on photographic material.

Our observations were made during three different runs at ESO, La Silla, in March and May 1988, and in March 1989, with the CCD cameras of the Danish 1.5-m and the ESO/MPI 2.2-m telescopes. We collected B and V images of 11 fields of the galaxy, distributed in such a way as to cover a total area of $\sim 21' \times 2'$. The six central fields were also imaged through an Hα filter (and in a contiguous band). Deep exposures and fair seeing conditions (FWHM = 0″.9–1″.2), allowed to measure stars down to magnitude $V \simeq 24$ using DAOPHOT. Instrumental magnitudes were calibrated by a large set of standard stars (Landolt 1983a, b). The zero point errors of our photometry are estimated to be ~0.03 mag in V and 0.05 mag in (B-V). Note that the comparison of ~200 stars in common with SC has revealed the presence of a systematic difference in the zero point, our photometry being 0.3 mag brighter than SC's; in other words, our scale implies a distance modulus 0.3 mag smaller than given by SC. The mean internal error, as given by DAOPHOT, ranges between 0.01 mag at V = 18 and 0.1 mag at V = 23. These figures, however, have to be regarded as lower limits of the internal errors, as shown by Piotto et al. (1990).

The final C-M diagram for 8250 stars identified in 9 fields is reproduced in Figure 2. Two fields were not observed under photometric conditions, and could not be accurately calibrated; moreover, ~15% of the stars happened to have formal error >0.1 mag, or $\chi > 1.8$ (Stetson, 1987), and were thus rejected. As can be seen, the brightest stars of the main sequence have V = 18, which corresponds to $M_V \simeq -8$. We like to stress here that, from the point of view of surface covered and number of stars measured, ours is one of the most complete CCD samplings of the stellar

TABLE 1: *Stellar photometry in dwarf irregular galaxies*

Object	Distance modulus	Ref.	Material used	No. of stars measured
NGC 6822	23.5 mag	1	phot.	–
		2	CCD	3475
IC 1613	24.5	3	phot.	318
		4	CCD	2224
WLM	25.0	5	phot.	68
		6	CCD	2250
LGS 3	25.0	7	CCD	66
GR 8	25.7	8	CCD	84
		9	CCD	142
UKS 2323	26.0	10	CCD	204
NGC 3109	26.0	11	phot.	–
		12	phot.	83
Pegasus	26.1	13	phot.	54
		14	CCD	–
Sextans A	26.2	15	phot.	70
		16	CCD	652
		17	CCD	2279
Sextans B	26.2	18	phot.	77
		19	CCD	1273
Leo A	27.1	20	phot.	92
		21	phot.	–
Sculptor	27.3	22	phot.	33
Ho I	27.5	23	CCD	279
Ho II	27.5	23	CCD	468
Ho IX	27.5	24	CCD	367
DDO 187	28.8	25	CCD	77

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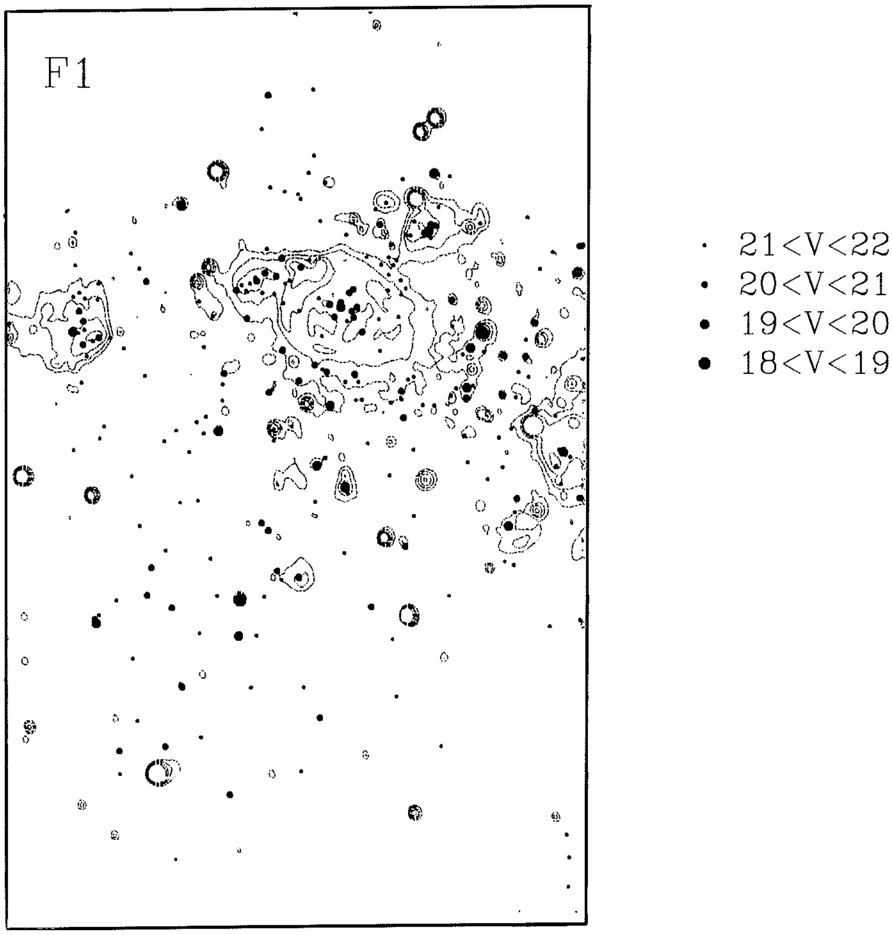

Figure 5: *Isophotes of the HII regions contained in one of the central Hα field of NGC 3109, superposed to the distribution of the brightest blue stars.*

content of a dwarf galaxy besides the Magellanic Clouds (cf. Table 1).

3. The Young Stars

The top panel of Figure 3 shows the distribution of the brightest blue stars, reconstructed by selecting only stars with $18 < V < 22$ and $-0.2 < (B\text{-}V) < 0.4$. In a similar way we have built the map of the brightest red stars [$(B\text{-}V) > 1.4$] shown in the lower panel of the same figure. The photometric data base pertains to 11 fields, covering more than 20′ of the galaxy in the direction of the long axis.

The central bar of NGC 3109, described by de Vaucouleurs and Freeman (1972), stands out in the blue map, together with the two eastern spiral arms, which are well seen in wide-field photographs. Moreover, the overall distribution of the blue stars appears rather clumpy. These structures are absent or barely visible in the red map, where stars seem more evenly distributed. We do not measure any appreciable difference in the scale heights of the two populations of stars.

The distribution of the young blue stars has also been compared to that of the H II regions provided by the Hα images. Very spectacular H II regions are present along and in proximity of the bar (Fig. 4). They are well confined to a ~300 pc thick stripe, with a maximum density a few arcminutes to the west of the optical centre. We have drawn the isophotes of these regions, and superimposed the blue star distribution. In general, the brightest blue stars and the main stellar associations are found inside H II regions, as can be seen in Figure 5, which reproduces one of the more central fields. The great star-forming region near the centre, just at the west end of the bar, is about 250 pc across.

We selected about 30 star-forming regions using the Hα images, and produced a C-M diagram for each one of them. The number of stars varies from a few tens to about a hundred. Due to the small angular size of these stellar associations, crowding effects are important, making the photometry rather uncertain at magnitudes fainter than V = 22. This approach has the advantage of isolating the young stars from the uniform background of old stars, which enables us to create a map of the most recent episodes of star formation over the whole surface of the galaxy image.

We have estimated the ages of the star-forming regions using theoretical isochrones kindly made available to us by the group of Prof. C. Chiosi. Unfortunately, internal absorption and metal content of NGC 3109 are still uncertain; therefore, only a rough superposition of the theoretical curves to the C-M diagrams is possible, allowing an arbitrary (but small) shift along the colour index axis. On the other hand, this procedure

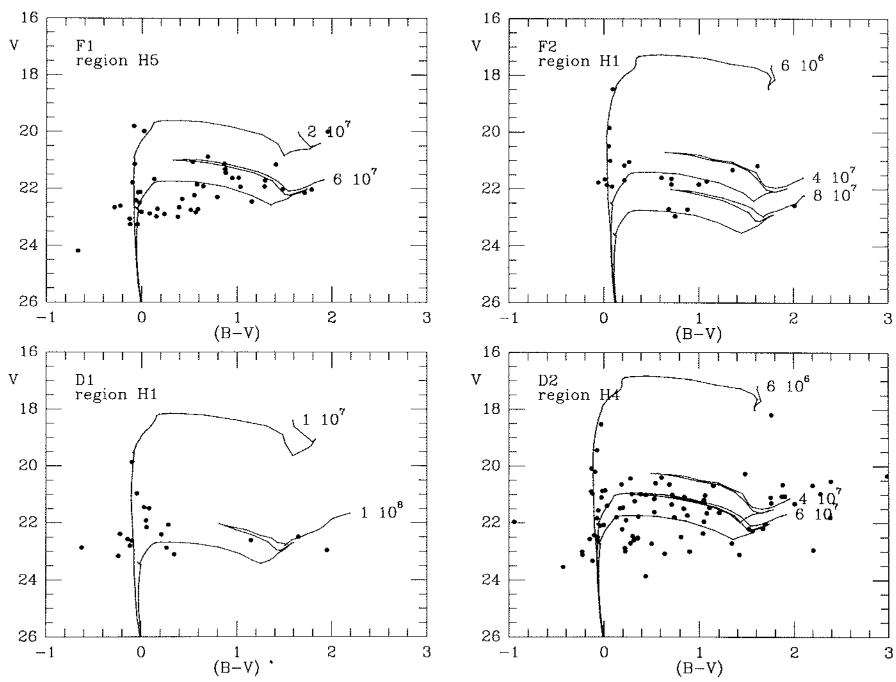

Figure 6: *C-M diagrams of four star-forming regions. Isochrones provided by C. Chiosi and calculated for a solar metallicity have been matched to the observations, allowing an arbitrary shift in colour. The corresponding ages (in years) are indicated.*

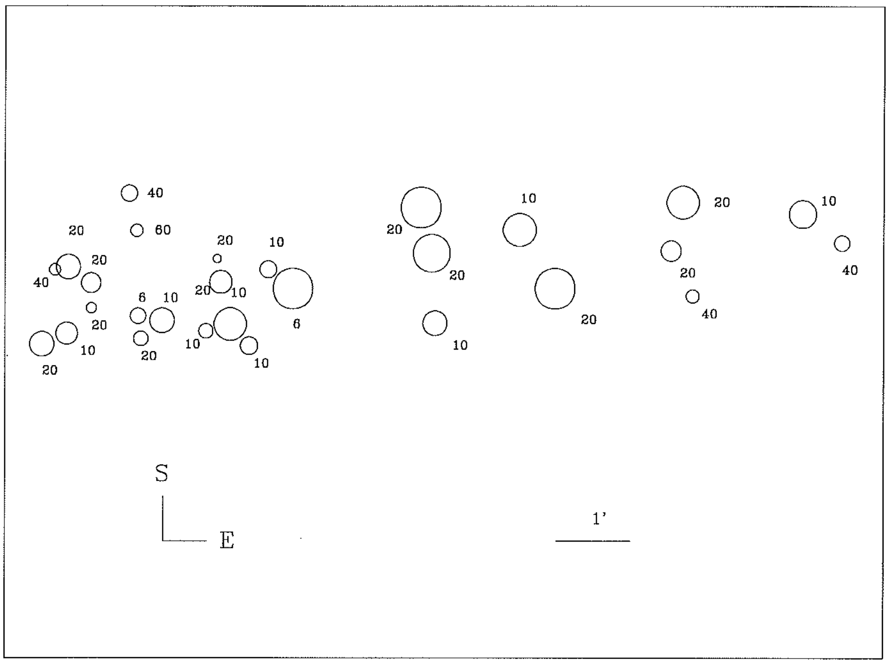

Figure 7: *Map of the star-forming regions selected in the six central fields; the radii of the circles are proportional to the size of the regions. Ages (in 10^6 yr) of the youngest stars found in the C-M diagrams are indicated.*

is accurate enough to get an estimate of the ages of the single regions. We have used models calculated for a solar metallicity and adopted the internal absorption values given by SC. A larger extinction correction had to be adopted for star-forming regions belonging to the central parts of the galaxy. An example of the procedure is shown in Figure 6.

We find that the youngest stars of NGC 3109 have ages of the order of $\sim 6 \times 10^6$ years, with masses $\sim 30\ M_\odot$; in other words, this galaxy is still active in forming stars. Moreover, since the part of the diagrams corresponding to ages of 20–100 million years appears rather uniformly populated by stars, we may conclude that, in this time interval, stars have formed in an almost regular manner (see the plot in Fig. 7, where sizes and ages of the selected regions are shown). A comparison with similar work on other resolved DIGs shows that the level of recent star formation in NGC 3109 is quite high, a fact which is probably related to the size of the galaxy.

Acknowledgements

We are indebted to thank G. Bertelli, C. Chiosi, and E. Nasi, for providing us with the isochrones for the massive stars in advance of publication. We also thank S. Ortolani for the Danish observations.

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Probing the Hidden Secrets of Seyfert Nuclei

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The nuclei of active galaxies are clearly among the most spectacular and violent places that can be found in our present universe. Most extreme are the bright Quasars, where we observe a total energy output equivalent to a large galaxy cluster from galactic core regions comparable in size to our solar system. In addition to optical and radio radiation we often observe intense X-ray and even energetic Gamma radiation as well as collimated streams of matter moving at velocities close to the velocity of light.

Most currrent theories assume that the enormous radiation power of active galactic nuclei (AGNs) is produced by massive rotating black holes residing in the dynamical centres of these galaxies. Swallowing surrounding material at rates up to about one earth mass per second, such black holes give rise to huge rotating magnetic fields and electric current systems which can explain the astonishing properties of these systems.

However, in spite of a large research effort during the past decades we are still lacking a reliable observational confirmation of the basic physical models of the AGNs and our knowledge of the detailed physical processes occurring in AGNs is still highly incomplete. One reason for the slow progress of our understanding of the AGNs is the great distance of most active galaxies which makes it impossible to resolve the active nuclei by direct imaging techniques. Furthermore, during the past decade it became increasingly evident that in many AGNs the central engines are not directly visible but hidden behind opaque dusty matter concentrations along the line of sight. Even in the case of nearby Seyfert galaxies (the nearest known examples of AGNs), direct optical radiation from the centre of the active nuclei seems to be observed only in exceptional cases. Moreover, when direct radiation is detected, it is often mixed with light of the normal stellar galactic core and with emission from circumnuclear normal H II regions ionized by stars.

Fortunately, modern observing techniques provide various methods to overcome some of the observational difficulties mentioned above. High-resolution spectroscopy often allows to separate the different components which contribute to the (on direct images) unresolved galactic cores. When the galactic cores are hidden from us by local dust absorption, their radiation fields can sometimes be determined indirectly from its effects on the interstellar gas in the host galaxies. Finally, recent progress in infrared imaging techniques makes it possible to penetrate part of the absorbing dust layers and to look deeper into the hidden central regions of the AGNs.

In this paper we shall report about our experience with these methods at the ESO telescopes during various recent observing runs. Because of limited space we shall restrict this report mainly to results on the two particularly interesting emission line galaxies NGC 5728 and IC 5063. NGC 5728 is a prominent barred spiral with a Seyfert 2 nucleus. An account of its basic properties and a photographic image of this galaxy can be found in an earlier issue of the *Messenger* (cf. [1]). IC 5063 (= PKS 2048-572) is an early-type radio galaxy known mainly for its pronounced dust lanes. In addition to data on these two galaxies, a few results on the prototype Seyfert 2 galaxy NGC 1068 will be reported.

Improving the Angular Resolution by Means of Spectroscopy

In the optical spectral range AGNs are usually identified by the characteristic emission line spectra produced in their Broad-Line and Narrow-Line Regions (BLRs and NLRs). Compared to most stellar spectra even the NLR spectral features are rather broad and have Doppler widths of several hundred km s^{-1} or more. Hence, on first glance it seems not to make sense to observe these spectra with high spectral resolution. However, as illustrated by Figure 1, high resolution spectra of AGNs can in fact provide important information. The upper part of Figure 1 shows long-slit spectrograms of the Hα and [N II] 6584 Å lines of NGC 5728 obtained with the ESO CASPEC spectrograph. The horizontal coordinate corresponds to wavelength (expressed as a relative Doppler velocity) while the vertical coordinate gives the location of the emission along the projected spectrograph slit. The centres of the two long slit spectra correspond (in velocity) to the systemic velocity of NGC 5728 (as derived from the absorption lines of the stellar component) and (in space) to the dynamical centre of the galaxy. Hence, a monochromatic light source emitting the corresponding spectral lines and moving with the centre of NGC 5728 would pro-

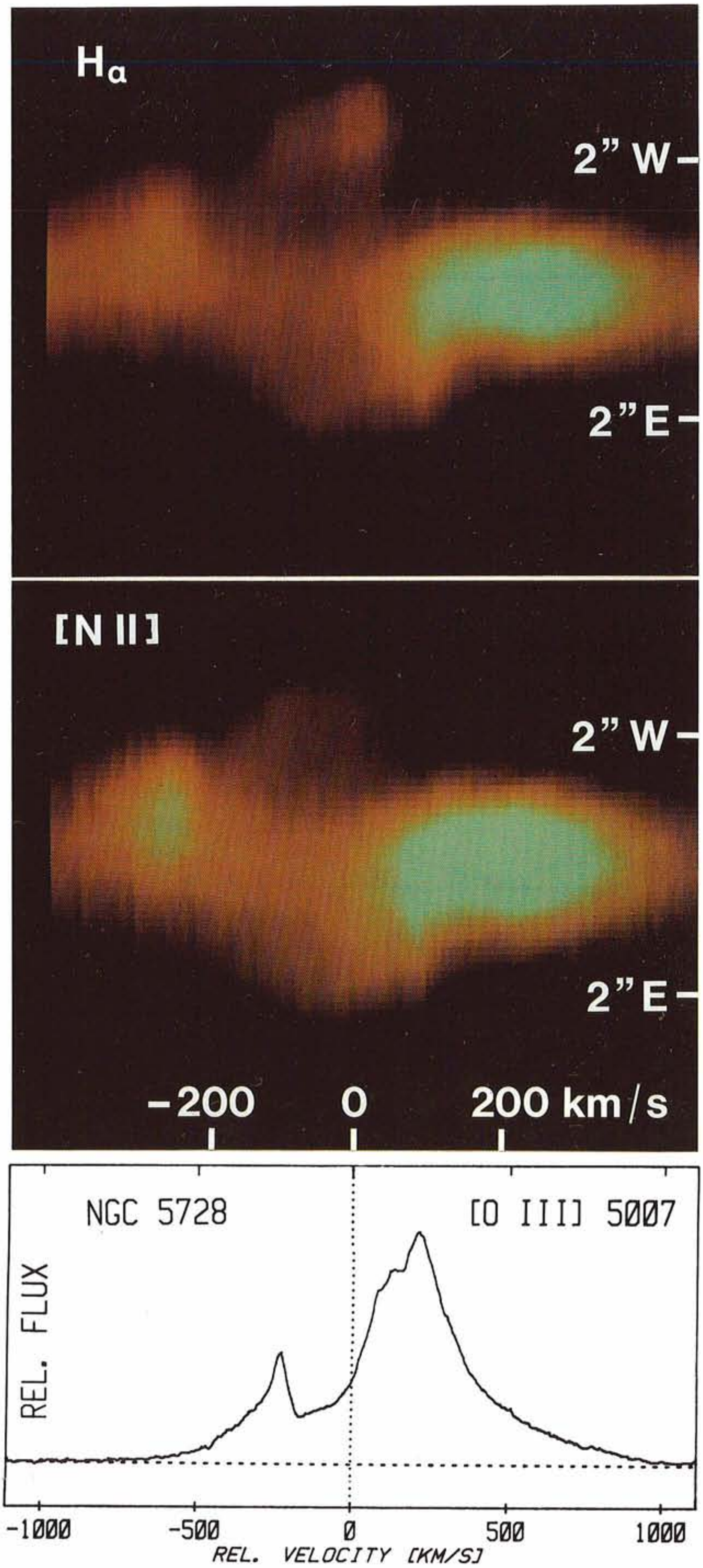

Figure 1: *Emission-line profiles of the nucleus of NGC 5728. On top are long-slit spectrograms of the cores of the Hα and [N II] 6584 profiles, obtained with an EW slit orientation. Below is a tracing (obtained by integrating along the slit) of the full [O III] 5007 profile.*

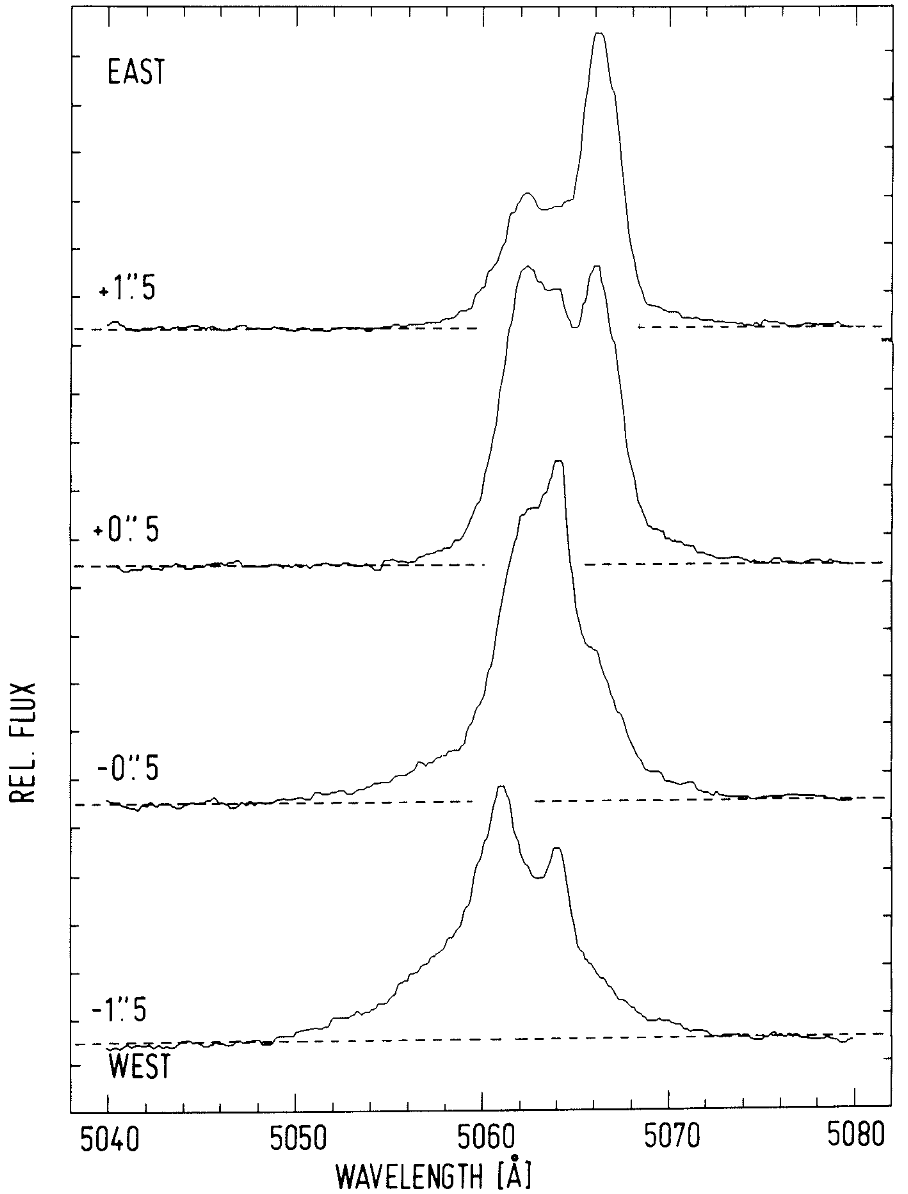

Figure 2: *Emission-line profiles at different angular displacements from the core of IC 5063.*

duce a point in the centre of each of the two images, while an extended monochromatic source would produce a vertical line.

As shown in Figure 1, due to the violent motion of the nuclear gas the line emission is distributed over a significant velocity range, producing the characteristic complex line profiles of the NLR (cf. [2]). Moreover, the emission is also smeared out in spatial direction. Although atmospheric seeing contributes to this spatial extension, Figure 1 (obtained with ≤0″8 seeing) clearly shows that much of the observed spatial extent is caused by the superposition of individual emission regions with different velocities and spatial locations. The highly different relative intensities of the individual components in the two line profile images show that the emitting gas volumes vary greatly in their physical conditions. As most of these emission components are concentrated in the innermost two arcseconds of the nucleus they cannot be resolved on direct images but become visible only on long slit spectrograms of sufficient spectral resolution.

A more detailed investigation (cf. [3]) shows that most of the emission line regions seen in Figure 1 correspond to measurably extended volumes of gas. Only the strongest component shows the angular intensity distribution of an unresolved point source. This component must correspond to the true Seyfert nucleus. Surprisingly, the nuclear emission, although projected on the dynamical centre of the galaxy, does not have the systemic velocity of the galaxy but shows a velocity shift of more than 200 km s^{-1}. This velocity shift is even more conspicuous in the tracing of the [O III] 5007 Å line (lower part of Figure 1), where the unresolved component corresponds to the redshifted peak.

A velocity difference of more than 200 km s^{-1} between the whole NLR and the dynamical centre of its host galaxy appears highly unlikely in all current AGN models. Hence, it seems much more plausible to explain the spectroscopic results by assuming that in the case of NGC 5728 only the red wing of the NLR profiles is observed, while the matter producing the rest of the NLR profile (i.e., in fact, most of the NLR) is hidden from us by dust absorption. With a slightly larger amount of dust absorption NGC 5728 could probably not even be recognized as an active galaxy.

Another example of the effects of circumnuclear dust in an AGN is shown in Figure 2, where we reproduce line profile tracings obtained for points on the major axis of the galaxy IC 5063 at various distances from the centre of the active nucleus. As the line again contains contributions of different volumes with different line widths and radial velocities, the NLR profile changes with distance from the centre. A surprising detail of Figure 2 is the fact that the profile observed at the centre is relatively narrow, while conspicuous broad line wings are present about 1″5 (corresponding to about 500 pc at the distance of IC 5063) NW of the dynamical centre. By separating the observed profiles into individual emission components, it can be shown that the broad wings are produced by a local emission region with a velocity width of about 900 km s^{-1} (cf. [4]). Such broad line components are expected to form only in the central regions of AGNs. The fact that such a broad emission profile is found from a region far outside the centre strongly suggests that we observe nuclear light which is scattered by dust clouds which are located outside the nuclear region and which are exposed to radiation from the nucleus. Since no broad wings are detected in the radiation reaching us from the direction of the nucleus, we again have to conclude that along our line of sight the core of the AGN is hidden by dust and that only indirect radiation is able to reach us at visible wavelengths.

The ENLR Connection

In addition to producing scattered light, the intense radiation field of the AGNs can also ionize the interstellar matter of their host galaxies. Depending on the UV flux and the matter distribution, the ionization effect may be significant even at distances of many kpc from the nucleus. The resulting "extended narrow line regions" (ENLRs) show the

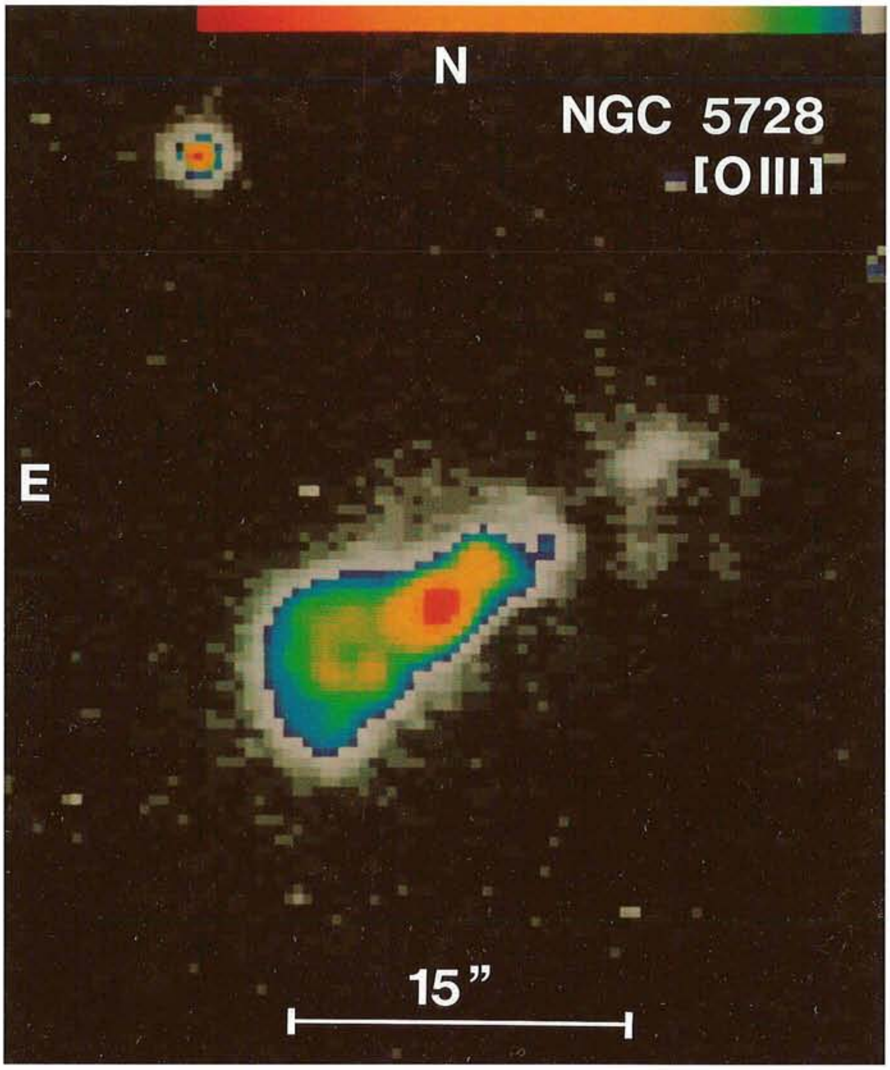

Figure 3: *False-colour map of the extended [O III] emission of NGC 5728.*

radiation from the centre of this AGN is visible in our line of sight.

Infrared Imaging

Since the scattering and absorption cross sections of typical interstellar dust grains decrease with increasing wavelengths, dust absorption is most severe in blue images of galaxies and becomes less important at red and infrared wavelengths. Therefore, dust absorption features are usually traced most efficiently by means of "ratio images" which are generated by calculating the ratios of corresponding pixels of two images obtained at different wavelengths. An example, showing the ratio between a visual (V-band) image and near-infrared (I-band) image of IC 5063 (observed by C. Möllenhoff and P. Surma), is given in Figure 4. As the dust absorption is weaker in the I-band (corresponding to about 0.85 μm) than in the V-image (central wavelength ≈ 0.55 μm) dust features appear darker in the ratio image. Figure 4 shows a particularly prominent dust lane just north of the nucleus. Since it almost coincides with the nucleus, it certainly affects the light reaching us from the core of this galaxy. The nucleus itself appears in the ratio image as a double peak. This is readily explained by the fact that its visual image is (due to stronger dust absorption) and a stronger contribution of extended line emission in the V-band) elongated while its I image is more circular.

same (nonthermal) ionization characteristics as the nuclear NLRs (and thus are easily distinguished from normal H II regions), but (due to lower internal velocities) differ from the NLRs by much narrower line profiles.

Figure 3 shows the ENLR of NGC 5728 as outlined by its [O III] emission. As demonstrated by the figure, most of the observed ENLR emission is found in two relatively narrow cones extending towards the SE and NW directions from the nucleus. Interestingly, the axis defined by these two cones also coincides (at least in projection) with a jet-like region of enhanced radio emission (cf. [5]). Such coaxial morphologies have also been found for other AGNs and have been interpreted as evidence for central radiation fields and relativistic particle flows directed mainly parallel to the rotation axis of the nucleus, while the radiation perpendicular to the rotation axis is blocked by a disk of dusty gas clouds. If this explanation is correct, and if the radiation cones of NGC 5728 are indeed oriented as suggested by Figure 3, it is obviously no surprise that little direct

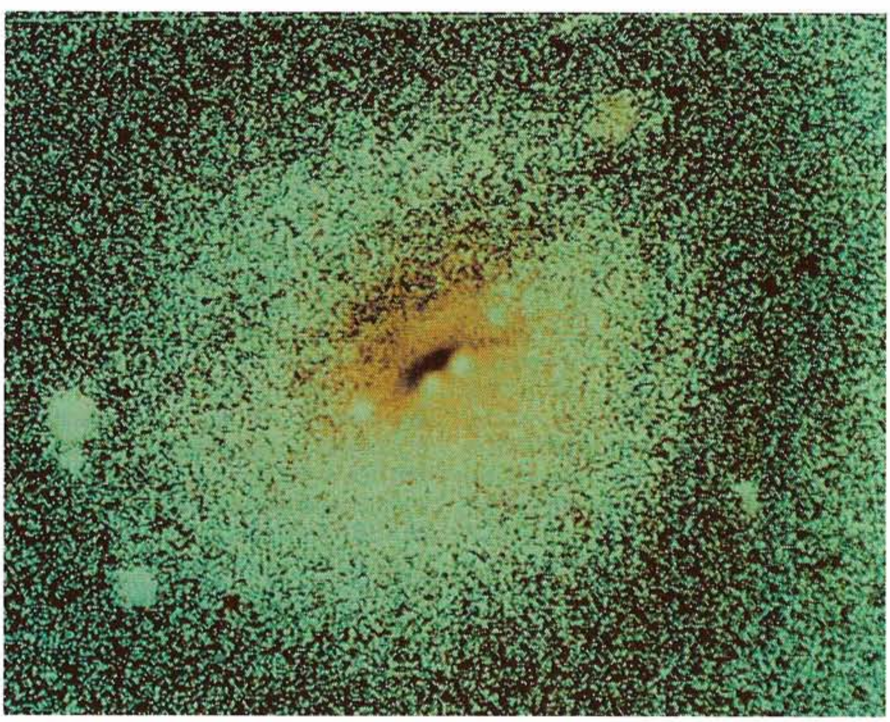

Figure 4: *V/I ratio map of the central part of IC 5063. The image covers about 2′ × 2.′5. North is up, east to the left.*

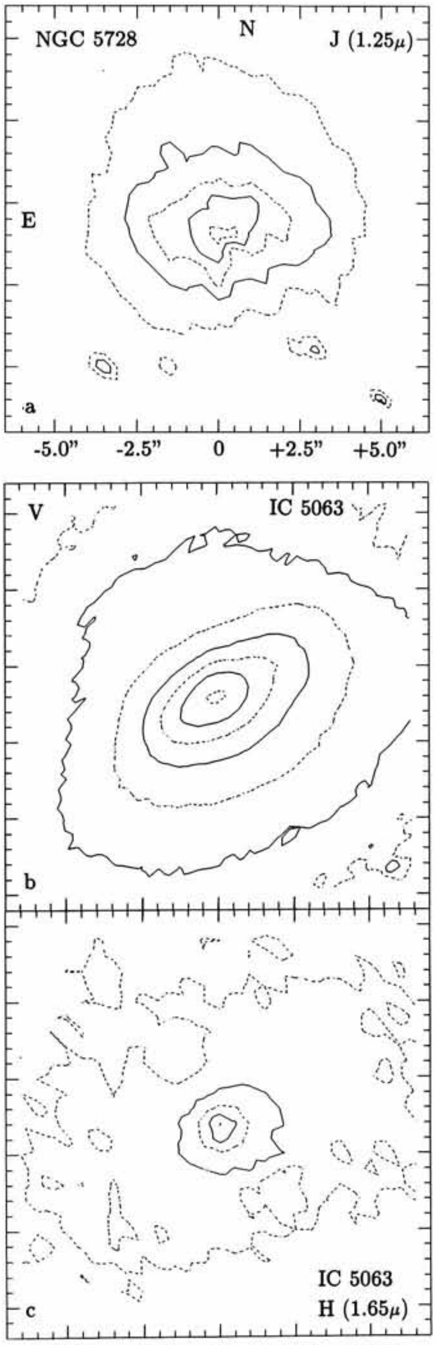

Figure 5: *Examples of broad-band images of the cores of NGC 5728 and IC 5063.*

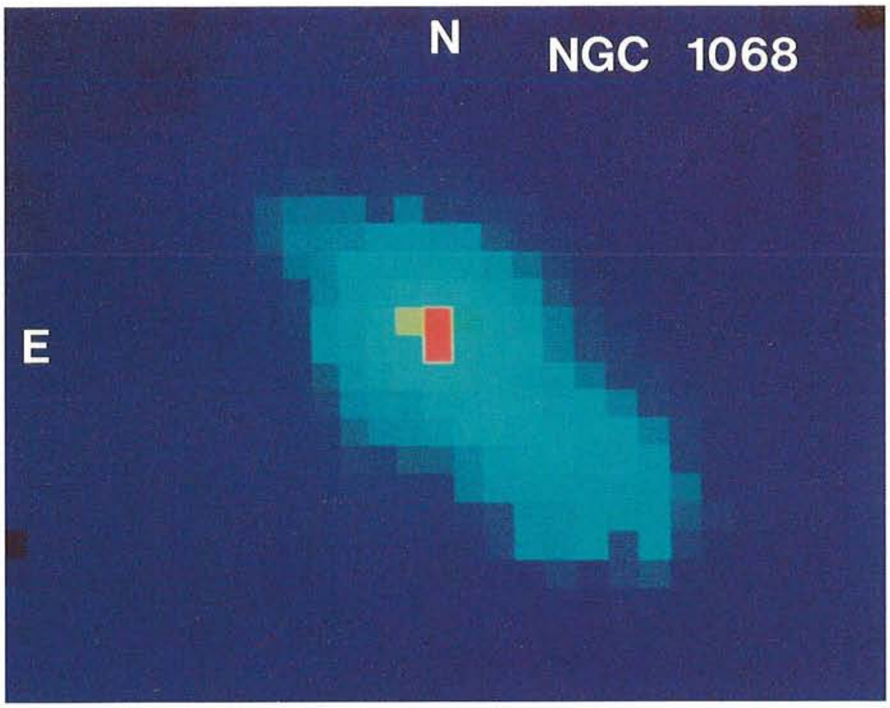

Figure 6: *False-colour map of the Brackett-gamma emission from the core of NGC 1068. The continuum has been subtracted by means of an image obtained in an adjacent narrow line-free continuum band. The image covers a field of 38″ × 48″.*

The ratio image of Figure 4 shows that I-band images (corresponding to the longest wavelength band that can be efficiently observed with normal Si CCD detectors) are clearly less affected by dust absorption than blue and visual images. However, a detailed analysis of our I-image shows that the dust lanes can still be traced even at these wavelengths and that the morphology seen in the I-band image is still influenced by the dust absorption. In order to look behind the dust, one obviously has to observe at even longer wavelengths. Therefore, we recently used ESO's new IRAC infrared array camera (cf. [6], [7]) to obtain images of several dusty Seyfert nuclei in the J (1.25 μm), H (1.65 μm), and K (2.2 μm) bands. Because of poor weather conditions and various technical deficiencies of the 32 × 32 pixel HgCdTe array available to us, our run was only a partial success. In the case of NGC 5728 only J-band images of sufficient S/N could be obtained. The IC 5063 observations were more successful, yielding images of reasonably good S/N in all three continuum bands and with different field sizes.

Examples of isophote maps derived from our IR images of the core regions of NGC 5728 and IC 5063 are presented in Figure 5a and c. In Figure 5b we show for comparison a V-band isophote map of the same area of IC 5063. Both IR isophote maps are based on images obtained with circular pixels of about 0.″16 diameter with a 0.″5 spacing. The (FWHM) resolution (limited by the seeing) is about 1.″2. The V map (based on 0.″35 densely packed and quadratic pixels) has a resolution of about 1.″5.

As illustrated by Figure 4, in the case of NGC 5728 most of the observed radiation in the 1.2 μm band is emitted from a slightly elongated extended region with an average diameter of about 7″ (corresponding to about 2 kpc). This region agrees well (in size, shape and orientation) with the area inside the ring of gas and stars which delineates the core of NGC 5728 on optical images (cf. [3]). Although the J-band emission reaches its maximum intensity in the centre, no distinct point source corresponding to the nucleus can be detected. The (in Figure 5 omitted) lower-intensity outer contours of the J-band intensity distribution become elongated along the (NE-SW) Major axis of the galaxy, indicating a low-level background produced by the stellar component. The extended IR radiation from the core region is probably also dominated by starlight, although extended line emission (e.g. of the Paschen lines of hydrogen) may contribute.

More interesting are the maps obtained for IC 5063. In all three IR-bands the observed radiation was found to consist of three distinct components. As illustrated by Figure 5c, the outer contours show an elongation along the major axis of the galaxy. The corresponding low-level extended emission again seems to originate from the stellar component. Superimposed is a small, about circular extended (diameter ≈ 4″) region which surrounds a prominent unresolved central point source. There seems to be little doubt that this IR point source corresponds to the Seyfert nucleus of IC 5063. A comparison of the V and the H maps of Figure 5 shows that the conspicuous isophote distortion by the dust lanes visible in the V map cannot be detected in the IR image, suggesting that absorption by these features is no longer significant at this wavelength. However, this has to be confirmed by a more detailed analysis of all three infrared frames.

The physical interpretation of the observed extended nuclear IR emission of IC 5063 is again complicated by the presence of emission lines in the three observed infrared bands. A separation of the line and continuum contribution requires narrower pass bands. Such narrow bands can be realized with the circular variable filter (CVF) of the IRAC camera. However, the detector noise of the present array limits this mode of operation to relatively bright objects. From published IR line fluxes only the nearby Seyfert 2 galaxy NGC 1068 appeared to be bright enough to attempt CVF observations. As this galaxy also belongs to the AGNs with evidence for a hidden core (cf. [8]) NGC 1068 was also included in our programme.

Our broad-band IR images of NGC 1068 show qualitatively similar properties as the IC 5063 frames. We again observe a bright unresolved nucleus surrounded by extended emission. Surprisingly, our narrow-band CVF images in line-free IR continuum bands turned out to be quite different. These images show the unresolved central nucleus but practically no detectable continuum radiation from an extended circumnuclear region. On the other hand, as demonstated by the Brackett-gamma line image reproduced in Figure 6, in the light of the IR emission lines we clearly see also extended emission surrounding the nucleus. Hence, in the case of NGC 1068 it seems clear that at least most of the extended circumnuclear IR emission is caused by line emitting gas.

Our results for NGC 1068 clearly demonstrate the potential of narrow-band IR imaging for studies of nearby AGNs. Hopefully, improved array detectors and larger telescopes will make it possible to apply this technique in the future also to other active galaxies including the hidden cores discussed in the first chapters of this paper.

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A Redshift Survey of Automatically Selected Clusters of Galaxies

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Introduction

The study of the large-scale structure of the universe provides direct constraints on the initial form of the density fluctuations from which galaxies, clusters and superclusters formed. This can be achieved by mapping the large-scale galaxy distribution, with the assumption that light is a good tracer of the underlying mass distribution. To compare our maps with the theory, we need to extract some numbers describing their properties in a statistical sense. One of the main properties which are of interest in this sense is *clustering,* i.e. how the distribution of objects differs from a random sample. This is of great importance, since theories usually give precise predictions about the level of clustering on different scales.

The most popular statistical estimator of clustering is certainly the two-point spatial correlation function $\xi(r)$, that measures the probability in excess of random of finding two objects at a separation r (see Peebles, 1980). One of the most remarkable results obtained in the last few years is that the two-point correlation function for clusters of galaxies (ξ_{cc}) is about 15 times stronger than that for galaxies (ξ_{gg}) (see Bahcall, 1988). This observation is one piece of evidence that has prompted the idea of biased galaxy formation (Kaiser, 1984) and indicates that neither galaxies nor clusters can both be tracers of the mass distribution. In the context of models of galaxy formation the "standard cold dark matter" model (CDM) fails to provide enough power on cluster scales when normalized to fit the observed ξ_{gg} (White et al., 1987).

Given the prime importance of this observation, it is extraordinary that we still rely on estimates of the cluster correlation function based on "eyeball" catalogues of clusters, namely the Abell (1957) and Abell, Corwin, Olowin (ACO, 1989) lists. Evidence has been accumulating about systematic and unquantifiable selection effects present in such visual compilations, giving rise to doubts on the reality of the observed ξ_{cc} (Sutherland, 1988, and see Dekel, 1989 for discussion). With these uncertainties in mind, the estimation of ξ_{cc} from a redshift survey of objectively (i.e. automatically) detected clusters is long overdue. In 1988 we started at ESO a redshift survey based on an automatic sample of rich clusters extracted from the Edinburgh/Durham Southern Galaxy Catalogue. The results (so far) have been very successful, and in this note we would like to report on the present status of the project.

The Automatic Catalogue of Clusters

As mentioned, the cluster catalogue has been extracted from the Edinburgh/Durham Southern Galaxy Catalogue (EDSGC), one of the first ever large-scale machine-based optical galaxy catalogues. This galaxy survey has been constructed using the COSMOS high-speed microdensitometer, and consists of 60 UK Schmidt J survey plates centred at the South Galactic Pole. The galaxy catalogue covers an area of 0.5 steradians to a limiting magnitude of b_j = 20, with a total of ~1.5 million galaxies, with > 95% completeness and < 10% star contamination (see Heydon-Dumbleton, Collins and MacGillivray, 1989 for details). The EDSGC represents an ideal

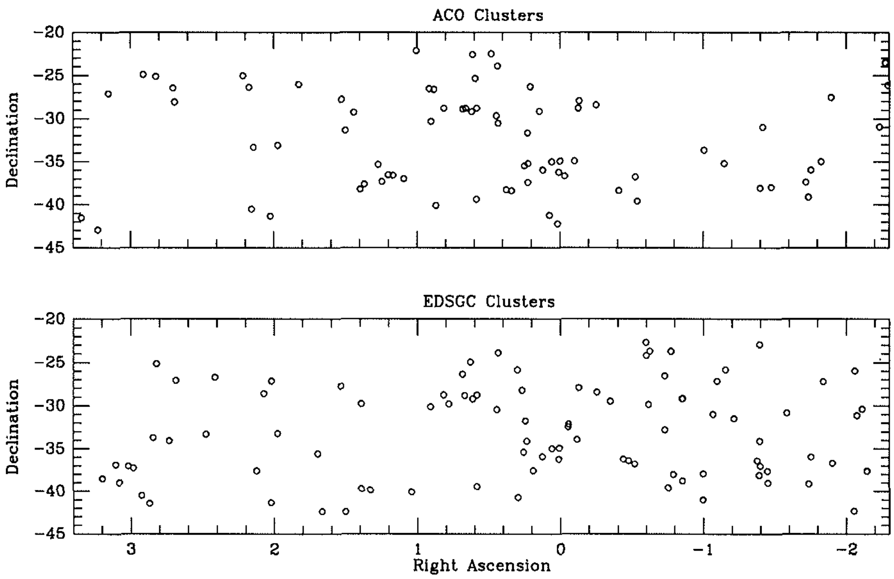

Figure 1: *Comparison of a subset of the EDSGC automatic cluster catalogue with a similar subset in the same area extracted from the ACO catalogue. Both subsets correspond to Abell distance classes ≤ 5. For the comparison of richness classes see the text.*

database for producing a cluster catalogue.

The first step in constructing our cluster catalogue was to produce a list of candidate clusters. The galaxy data were binned into 5 arcmin pixels and then smoothed with a gaussian filter to reduce the harshness of the binning. To avoid preferentially detecting clusters in high-density regions of the survey while missing others in low-density regions, we must remove the large-scale galaxy distribution. This was achieved by heavily smoothing the pixel data with a median filter on the scale of 1.5 degrees and then subtracting this sky background estimate. Projection effects have been proposed to account for part of the discrepancy between ξ_{gg} and ξ_{cc}. We took particular care then to reduce their influence by deblending the candidate clusters. Each of them was re-thresholded at 16 equal levels above the local sky background as estimated above. If any saddle-points in the candidate's pixel data were found, the candidate was then split into its daughter members. After the completion of the redshift survey we will be able to check residual projection effects by deblending in 3 dimensions, using the magnitude and redshift distribution of the cluster members. The total number of candidate clusters detected over the 1700 deg^2 of the EDSGC survey is ~ 1000 (Nichol et al., 1990).

Abell estimated the distance to a cluster using the magnitude of the tenth brightest member (m_{10}). The cluster's richness was defined as the number of galaxies within a fixed radius (scaled to the cluster distance) in the magnitude range between m_3 and m_3+2. Our first candidate analysis was the same as Abell, as any new cluster catalogue must be initially compared to the Abell (or ACO for the South) catalogue. The final catalogue contains ~ 300 clusters with > 30 members. Of these 65 % are present in the ACO catalogue, yet we only detect 30 % of the ACO's clusters in our survey region. Upon checking the missing ACO clusters we find they are of low richness, or not a cluster at all, while the new non-ACO clusters are all rich bonafide clusters. The clusters common to the two catalogues show slight distance correlation but we find no relationship between our richness and ACO richness. In Figure 1 we show a plot of the sky distribution of the Automatic Clusters (AC), while Figure 2 shows an EFOSC direct image of the central regions of the new cD cluster AC-22.

Observational Strategy

In 1987 while the construction of the cluster catalogue was in its early stages, we realized how efficiently we could construct a cluster redshift survey by using EFOSC in MOS mode at the ESO 3.6-m telescope. We intended to observe around 10–15 galaxy redshifts per cluster on a sample of about 150 clusters and for this EFOSC was more suited than OPTOPUS, the fiber large-field multi-object facility. Indeed, with this number of spectra and with a good filling factor of the CCD field (as it is the case for most of our clusters) the use of EFOSC is to be preferred to OPTOPUS both in terms of efficiency and flexibility. On the other hand, OPTOPUS is best suited to investigate in detail problems like subclustering, where many redshifts are needed on every single cluster. In this sense, our programme is complementary to the key programme of Mazure et al. (1989), where the emphasis is more on studying detailed structure.

The observing programme was started in August 1988, with a first allocation of 3 nights at La Silla, and received generous attention from the OPC in the following semesters, especially as we did not ask for the official long-term (i.e. key programme) status. The total number of nights allocated so far is 12, over four semesters. During these two years of use, EFOSC has proved to be an excellent device for this kind of redshift survey. With some good luck with the weather, we could observe at high efficiency about 75 % of the time. We covered 62 clusters, with a total of ~ 800 galaxy spectra.

The observational set-up of EFOSC includes the B 300 grism, providing a spectral coverage from 4000 Å to 7000 Å with about 6 Å/pixel. The use of the cross-correlation technique to measure the redshift reduces the actual rms errors to 50–100 km/s, depending on the S/N ratio of the spectra. With 10–15 measured galaxies per cluster we have negligible errors on the mean redshift (< 200 km/s). Exposure times of 20 to 30 minutes have been used to obtain good S/N spectra for the faintest objects (b_j = 19) observed. Accurate positions (< 2″), magnitudes (< 0.2) and image classification for all the objects in

Figure 2: *EFOSC direct image of the automatic cluster AC-22 at redshift z = 0.1079.*

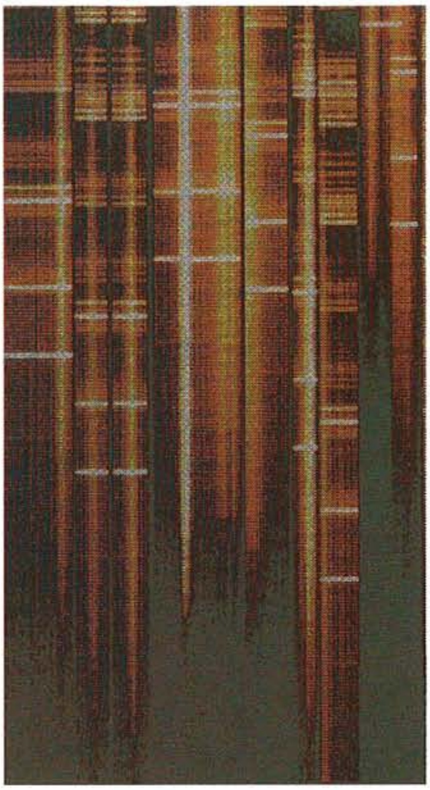

Figure 3: *MOS frame of galaxies in the field of AC-22. The quality of cosmic ray events elimination through AVERAGE/WINDOW is evident.*

each cluster, all information provided in the EDSGC, have proved to be very useful to maximize efficiency. We can produce high-quality finding charts and decide well in advance where the areas best suited for MOS are in each cluster. In this way we decide the optimal position angle of the rotator for including as many spectra as possible on the CCD frame.

Mask preparation with PUMA has proved to be quite simple. After some practicing we decided to use quite short slitlets (10 arcsec) to guarantee flexibility during the initial selection of slit positions. This small size allows the spectra to be packed more closely to each other if desired, while on the other hand longer slits can be built by simply overlapping many slitlets. This is much simpler than the standard procedure involving the construction of a different IHAP table for each chosen slit length. A decision on the best length can then be taken directly on the specific area. There is always a compromise between the desire to observe as many objects as possible and the necessity to perform a good sky subtraction, and this compromise is obviously dependent on the surface distribution of objects and on their magnitudes. Figure 3 shows the MOS frame for AC-22.

To increase our global efficiency and reduce the time necessary to complete the project, we decided last year to complement ESO observations using the AUTOFIB fiber system at the 3.9-m Anglo-Australian Telescope. AUTOFIB is similar to OPTOPUS, but with the advantage of having an automatic fiber positioner which greatly improves the observing efficiency. Indeed, during 3 nights in October 1989 we secured another 30 clusters.

Data Reduction

The aspect that makes Multiple Object Spectroscopy so interesting and useful is the tremendous increase in the number of spectra that can be obtained in one night with respect to the standard method. This implies that automatic data reduction techniques become a must to avoid being overwhelmed by the data flow. Future MOS devices will certainly have to include as much on line reduction as possible, otherwise data handling will become prohibitive. For the time being the astronomer has to solve the problem in the reduction phase. Unfortunately, no specific package has been developed for this kind of data inside MIDAS, and therefore we had to construct some routines to extract and handle the single spectra from their parent multi-object frame. This implied an extra effort in the beginning, that however improved enormously the efficiency of later reductions. Presently, reduction has become a routine job and we can transform a whole MOS frame into a set of ~15 1-D calibrated and sky subtracted spectra in about two hours. To wavelength calibrate the single 2D spectra extracted from the MOS frame we use the standard commands in the long-slit context (IPCS in the old MIDAS). In Figure 4 we show a final 1D spectrum from the same cluster of Figures 2 and 3, i.e. AC-22.

The next steps follow essentially the recipe by Tonry and Davis (1979) for an optimal treatment of the spectrum before applying the cross-correlation algorithm. These involve, among others, rebinning into logarithmic bins, elimination of residual spikes (emission lines, residual cosmics and sky lines), continuum subtraction, endmasking and bandpass filtering. Finally, cross-correlation with several galaxy templates is performed using the Fast Fourier Transform method. To calibrate the zero point of the galaxy templates, we have also observed high S/N nearby objects with very good 21-cm redshift determinations.

Future Prospects

With another 5 nights at ESO and a similar amount at the AAT we will be able to complete the first homogeneous sample of about 150 clusters with richness >30 and distance classification ≤5 (with m_{10} in R ≤ 17.2). This will then provide an excellent database for estimating ξ_{cc} with a higher accuracy than previous measurements (Bahcall and Soneira, 1983; Sutherland, 1988).

Apart from the main goal of the survey, i.e. ξ_{cc}, the complete sample of 150 clusters will be used to initiate a number

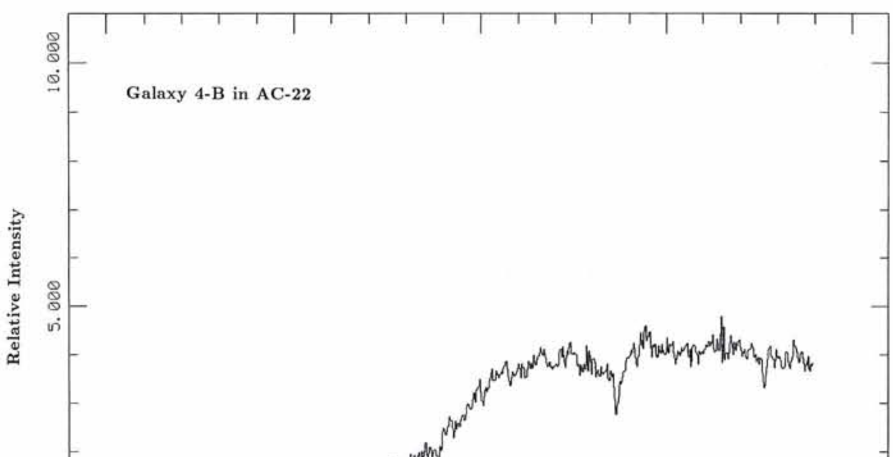

Figure 4: *Spectrum of the 18-magnitude cD galaxy in AC-22 (z = 0.1071). Note the good quality of sky subtraction and the number of absorption features. Total exposure time in this case is 30 minutes.*

of parallel studies. We intend to study: (a) the luminosity function of cluster galaxies (we have b_j magnitudes from the EDSGC) and its relations with the dynamical state of the parent cluster; (b) velocity dispersions and substructure in those clusters with a large enough number of redshifts. These are just some examples of the wealth of scientific information contained in our cluster redshift survey. However, the most exciting results will probably be those we cannot foresee at present, as it has always been the case when new large-scale redshift surveys have been performed.

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Comet Austin Rounds the Sun

R.M. WEST, ESO

Modern astronomers are privileged people. They exert a profession which for many is also their hobby; they receive good support from the authorities; they have the attention of a broad public and they work in a field which in virtually all respects is above political and ecological concerns.

It even appears that they no longer run the risk of being punished when they make imprecise predictions ... Astronomers nowadays only rarely think of their pitiful eastern colleagues who long ago forgot to predict an eclipse and promptly lost their jobs, heads and lives.

Of course, in the meantime the computations needed to establish the exact time and place of a solar eclipse one hundred years from now have become so accurate that tour organizers may safely start the preparations and book the hotels already now. On the basis of the collective experience gained during several centuries we now master celestial mechanics to a very high degree of perfection and Voyager was guided to within a few kilometres of the aiming point at Neptune, more than 4000 million kilometres away.

Comet Brightness Prediction: A Difficult Art

But such a high degree of perfection is less evident when we turn to the brightness of comets. Indeed, in this field we astronomers have several times been in situations similar to those frequently experienced by our exposed meteorological colleagues, especially before the advent of remote-sensing weather satellites. Why, demanded the angry public, why did we leave our umbrellas at home and got wet when you predicted sunny weather? And why, yes why did you astronomer "experts" say that the comet would become so bright that it could be seen with the naked eye, and then I could hardly find that weak patch of nebulosity in my new expensive telescope, specially bought for this "unique" event?

I do not blame the public reaction, for I have had this experience myself in early 1974 when I tried to locate Comet Kohoutek from a balcony in brightly lit Geneva where I lived at that time. And I had a feeling of "déjà vu" when I searched for Comet Austin in the morning sky from the roof of my home in Munich in late April this year.

In old days, the appearance of comets was always unexpected and it often brought fear to monarchs and other rulers – no doubt that such events were often cleverly interpreted by sly counsellors to their own advantage. These times have passed and in our days the discovery of a new comet, especially one in a near-parabolic orbit and therefore "new" in the sense that it has never before been near to the Sun, rather makes some astronomers worry about how accurate their brightness predictions will turn out to be.

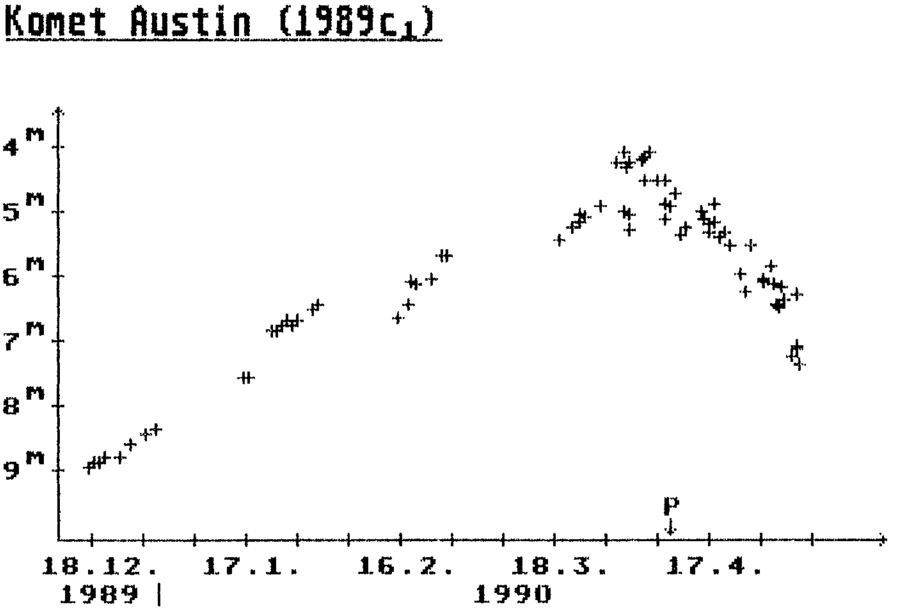

Figure 1: *Heliocentric brightness evolution of Comet Austin, showing the rapid decrease after perihelion. Prepared by Andreas Kammerer (Karlsruhe, Fed. Rep. Germany).*

Figure 2: *Comet Austin, observed on April 20, 1990 by Michael Jäger (Fischamend, Austria). The impressive tail measures more than 4.5 degrees. Exposure time 4 min on Kodak TP 2415 emulsion.*

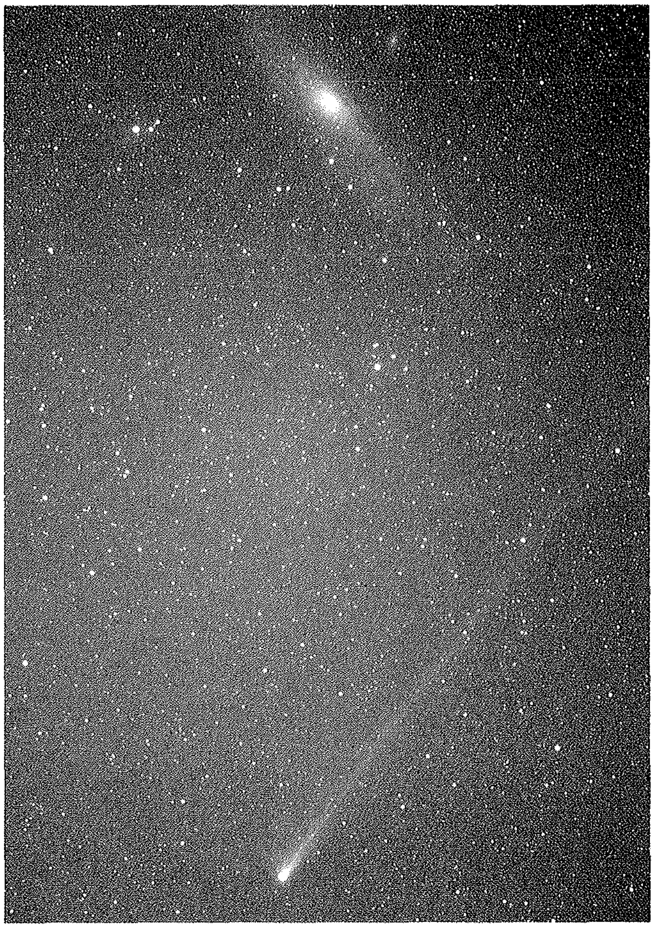

Figure 3: *Comet Austin, near the Andromeda Nebula, photographed on April 24, 1990 by Stefan Binnewies (Bochum, F.R. Germany) 5-min exposure on Agfachrome 1000 RS.*

The problem is particularly intricate when the new comet, as was the case for Kohoutek and Austin, is discovered while it is still quite far from the Sun and already appears unusually bright at this distance. Then the temptation is great to make a simple extrapolation and to predict that the comet will become a really bright object near perihelion.

Why Was Comet Austin Not So Bright?

When Austin was discovered in early December 1989, more than four months before perihelion, it was well outside the orbit of Mars, and already of magnitude 11. This is unusually bright at this distance. If it would behave like most periodical comets, it could be expected to reach magnitude 0 near perihelion in early April; indeed, the brightness increase in December and most of January seemed to confirm this trend. The first doubts arose in February when it appeared to become rather diffuse and in mid-March it was evident that Comet Austin was falling behind the predicted brightness. In the end, it stalled around magnitude 4.5–5.0 at maximum, with about magnitude 5 in late April, the time when it was ideally suited for observations from the Northern Hemisphere. The heliocentric brightness change (i.e. the brightness the comet would have at 1 A.U. geocentric distance) is shown in Figure 1. An asymmetry around the perihelion is clearly visible – the brightness falls more rapidly off after the perihelion.

There are probably two reasons for this. First, several of the "new" comets discovered during the past decades have been unusually bright at large heliocentric distances, possibly because there were small deposites of various ices (H_2O, CO_2, . . .) on the surface of their "dirty snowball" nucleus. This layer evaporates already at large distance and forms a temporarily dense coma around the nucleus. But the deposites are soon exhausted and then the coma becomes thinner and more diffuse, and the brightness stalls.

The second is the lack of dust in some comets, and this is probably the most important reason in the case of Comet Austin. The visual brightness of a comet is largely determined by the amount of dust in the coma, which effectively reflects the infalling sunlight. When more dust comes out of the nucleus, then there will be more in the coma, and the comet will be brighter. We do not know yet why some comets are more "dusty" than others; it could be a real difference in composition, or it could simply be that in some comet nuclei, the dust "pockets" happen to be nearer the surface and therefore more readily replenish the coma via "dust jets".

Whatever the reason, it is clear that we cannot with confidence predict a comet's brightness without knowing the size, structure and composition of its nucleus in some detail. For periodical comets, experience has taught us that they behave more or less the same way at each return and that straightforward extrapolations are reasonably secure, as was the case with Comet Halley in 1986. But "new" comets are also new to us, and we have no observational means to study their nuclei in detail. For the time being, we can only treat them in a statistical way, hoping that they will behave "normally".

However, comets are real individualists, and we must endeavour to base our brightness estimates on the best possible observations. In particular, the approximate amount of dust can be judged from infrared observations and

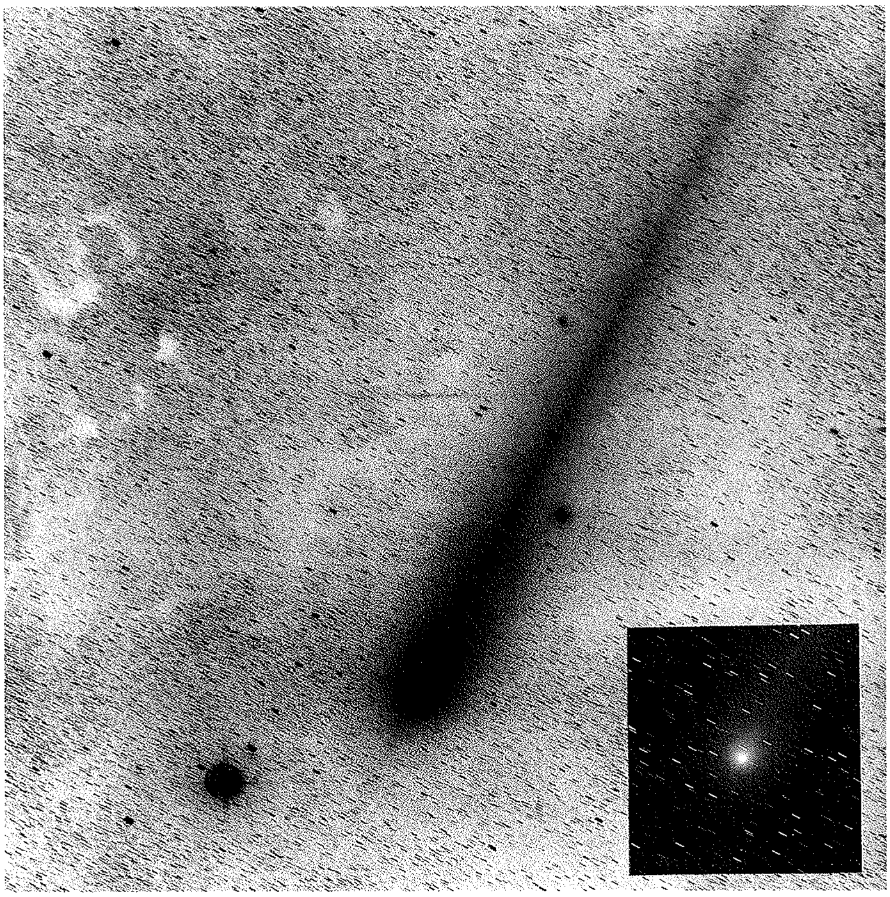

Figure 4: *Comet Austin is here seen on a 10-min B exposure (IIa-O + 66 385), obtained by Guido Pizarro with the 1-m ESO Schmidt on June 5.39, and photographically enhanced by Hans-Hermann Heyer, ESO-Garching. Of particular interest is the so-called "neck-line" structure which is seen as a 1.5-arcmin wide, straight dense structure, stretching at least 2.6 degrees (to the plate border) within a broader, diffuse and rather faint envelope. A much weaker sunward spike can be followed in the opposite direction to about 30 arcmin distance from the nucleus. Both features represent sunlight reflected in dust particles ejected from the comet, and are visible when the Earth crosses through the comet's orbital plane. They were predicted by M. Fulle (Trieste) and L. Pansecchi (Bologna) in April 1990 (IAU Circular 4991). The insert shows the region around the nucleus.*

we ought to take such measurements more into account in the future.

Observations of Comet Austin

All of this should not hide the fact that Comet Austin was still a relatively bright comet with a fine tail and a good study object for both professional and amateur astronomers. Many photometric and spectroscopic observations were performed with large telescopes and quite a few amateurs took impressive photos; two are shown here (Figures 2 and 3). While this comet may have been another "flop" for the general public, it was a good opportunity to make use of the means and methods from the Halley campaign.

Observations at La Silla began in late May, when Comet Austin crossed the celestial equator and again became accessible from the southern hemisphere. There was too little time to prepare a detailed summary for this *Messenger* issue, but it is expected to bring more information in one of the next issues. In the meantime we reproduce here one of the first photos (Figure 4) taken with the ESO 1-m Schmidt telescope in early June.

We know for sure that a really bright comet will appear again sometime – statistically there are about 4 to 5 such objects per century. But we cannot predict when this will happen . . .

A Delicate Postscriptum

Maybe we astronomers should learn to better resist the pressure of those media who want sensations. When we make an – admittedly not very accurate! – prediction of a comet's maximum brightness, say, as magnitude 0 ± 2, many journalists have a built-in tendency to overlook the plus-sign; it is a safe bet that you will read in the press that the comet is expected to reach "–2 mag or possibly brighter" and become as bright as the brightest planets. And when the comet after all only reaches magnitude 2, then we are asked why we were off by 4 magnitudes . . .

Acknowledgements

I am grateful to Werner Celnik (Berlin), Jürgen Linder (Durmersheim), Andreas Kammerer (Karlsruhe), Michael Jäger (Fischamend) and Stefan Binnewies (Bochum) for information and photos.

Asteroids: A Key to Understand the Evolution of the Solar System

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1. Introduction

Asteroids are believed to be remnant planetesimals from the crucial period of planetary formation and are mostly located in the transition region, separating the terrestrial planets from the jovian ones. There the planetary formation process was interrupted at an intermediate stage owing to an unknown mechanism, probably associated with the gravitational influence of the massive proto-Jupiter.

Asteroid eccentricities and inclinations were pumped up, thereby increasing collision velocities, and transforming

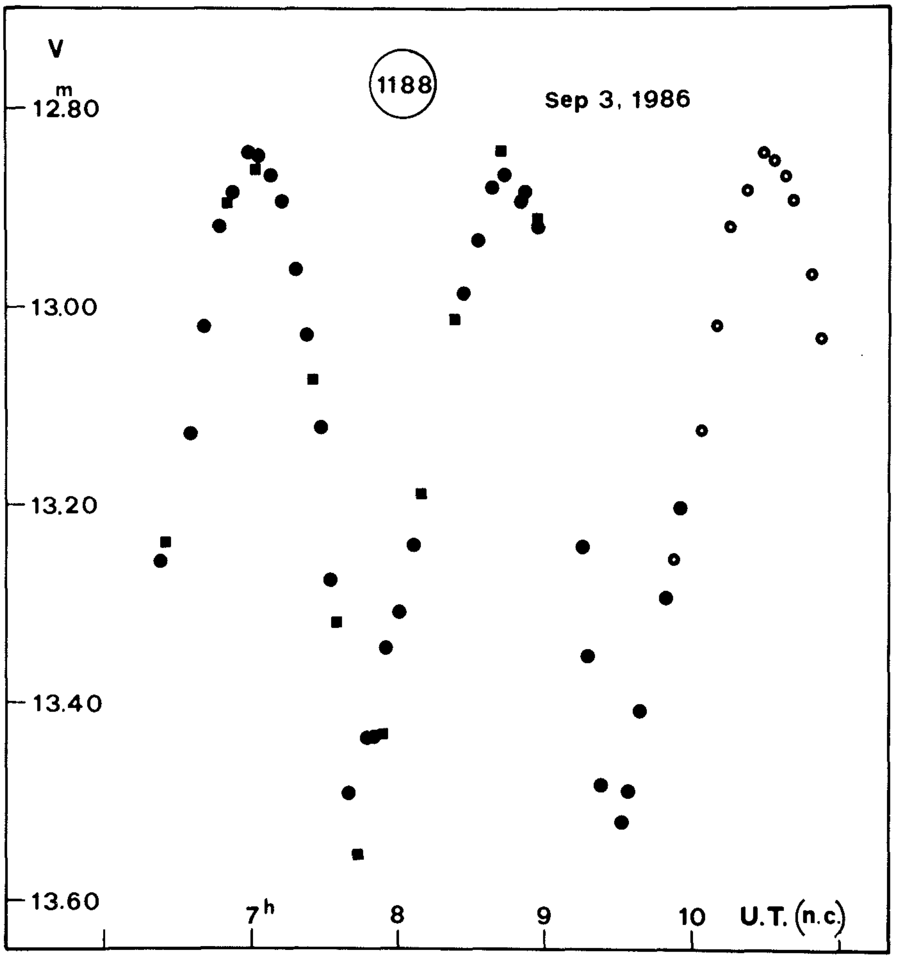

Figure 1: *Composite lightcurve of asteroid 1188 Gothlandia obtained on September 2–3, 1986 with the 1-m telescope at La Silla. The obtained rotational synodic period is 3.493 ± 0.07 hours and the lightcurve amplitude 0.67 ± 0.01 mag.*
(■) Sep 2; (●) Sep 3, 1986. Open symbols are repeated points.

the accretion among planetesimals into collisional destruction and erosion. Impacts have altered asteroid sizes, physical structures and rotation rates over the course of solar system history; however, the magnitude of these changes is not yet well understood. Collisional comminution among the asteroids continues to the present.

Asteroids comprise a great diversity of objects, with wide variations in mineralogy, in size (sub-km to 950 km in diameter), in spin rate (a few hours to two months), in shape (spherical to elongated or even binary), and in solar system location. Most of them should be constituted of essentially unaltered primitive material in which is preserved important information about the chemical composition and the environmental conditions of the protoplanetary nebula and the processes that produced the planetary bodies: asteroids would represent the last remnant of the swarm of planetesimals which formed the terrestrial planets.

Even though asteroids remain points of light through ground-based telescopes, the knowledge of these small bodies has considerably improved over the last twenty years, but the asteroid population is still poorly known with respect to the other bodies of the solar system which have been explored by spacecraft. Ground-based observations provide the only available information.

Most of the current knowledge on asteroid rotational properties (rotation period and pole direction) and on their shapes is deduced by analysing the amplitude and the behaviour of the lightcurves obtained by photoelectric and CCD photometry. Surface albedo homogeneity is estimated on the basis of three- or eight-colour photometry; chemical composition of the surface materials is deduced comparing the IR reflectance spectra of asteroids with those of different materials (meteorites, lunar and terrestrial rocks, etc.) obtained in the laboratory, while significant contributions to the knowledge of the physical properties of these materials have been obtained by radiometry and polarimetry and on the basis of the few available radar observations. Star occultations and speckle interferometry give better data on asteroid shapes and pole orientation, but these measurements are difficult and only few data are presently available.

Editor's note: This paper is published in response to a request from the ESO Observing Programmes Committee, whose members suggested that an overview of current theories of asteroid formation, etc. should be prepared. We are thankful that Drs. Di Martino, Barucci and Fulchignoni have taken on this task and feel sure that many readers of the *Messenger* will appreciate this concise summary of minor planet work.

2. Current Knowledge

2.1 Rotation

Asteroid magnitudes vary periodically as they spin, mostly because of changes in cross section for nonspherical bodies but also because of surface albedo variations and scattering anomalies. Amplitudes are typically 0.1 to 0.3 mag but can exceed 1 mag. To date, there are about 4500 numbered minor planets, and we know the rotation periods of about 600 objects, but the rotation data set for the smaller objects is very incomplete when compared with the rotation periods available for asteroids larger than 100 km. In fact, only less than 10% of objects with diameter smaller than 50 km have been observed and have a well-determined rotation period, while the percentage is 30–40% for objects of about 100 km, and close to 100% for asteroids larger than 200 km. It follows that special efforts should be made to enlarge the available set for the smaller asteroids.

The first lightcurve of a minor planet was obtained in 1901 of 433 Eros, and in the next years light variations were observed for several other asteroids, at first by unreliable photographic photometry which was replaced in the 1950s by photoelectric photometry. In general, we can assert that asteroids are irregular bodies, partially spotted by albedo features. However, the contribution of this second characteristic is very small when compared to the variation of the projected shape during rotation. Lightcurves dominated by shape exhibit two maxima and two minima per period (see Fig. 1) for obvious geometrical reasons. Variability due solely to albedo features can yield any number of maxima per period, but most commonly one. When the lightcurve is dominated by albedo variegations it is possible to have ambiguity in determining the rotation period (Zappalà et al., 1983). A few asteroid lightcurve amplitudes are too small to reveal reliable rotation periods.

Plotting the available asteroid rotation rates versus their diameter by a so-called "running box" technique, that was first used for asteroid rotation rates by Dermott et al. (1984), there appears to be an increase in the rotation rates for very large objects, relative to the smaller ones (see Fig. 2). It is as if the marked change in the rotation-diameter distribution at sizes of about 100 km may separate primordial asteroids (right) from their collisional products (left). A possible trend towards more rapid rotation rates is present among the very small asteroids, but there is also an excess of slowly rotating objects below a size of about 50 km (this is evident in the figure from the increase in the dispersion for the lower size range), and the distribution of rotation rates among the smallest asteroids is distinctly bimodal. Unfortunately, for these objects the results are only indicative because, as already noted, they are affected by the incompleteness of the data set.

2.2 Shape

We have some indications on asteroid silhouettes that can be derived from star occultations, which give the cross-sections of asteroids in the plane perpendicular to the line of sight. Although this result is aspect dependent, star occultations (Millis and Dunham, 1989) indicate that larger asteroids have either a spherical or an ellipsoidal shape, while radar delay-Doppler images of small asteroids (Ostro, 1989) show more irregular shapes. On the hypothesis that the asteroids evolved collisionally from planetesimal swarms, these observations can be easily interpreted: the largest bodies (D $\geqslant$ 200 km) are the remnants of the original population characterized by equilibrium figures, while decreasing the size increases the number of irregularly shaped asteroids, affected or produced by disruptive collisions. This interpretation is confirmed by the most recent results from experimental studies of catastrophic fragmentation processes (Fujiwara et al., 1989, Capaccioni et al., 1986).

The images of the smaller bodies of the solar system (satellites of Mars and minimoons of Jupiter, Saturn and Uranus), obtained during space missions, show that elongated shapes are common in the size range 20 to 200 km. For this reason, bi- and triaxial ellipsoids seem to be a realistic approximation of the shape of most asteroids.

The lightcurve of an asteroid constitutes the primary observational data needed to determine its shape and pole direction. Much work has been carried out to determine these parameters from the observed light variations, also by comparing the observations with laboratory simulations that help in understanding how each parameter (shape, orientation and surface morphology) influences the lightcurve (Ostro and Connelly, 1984; Barucci et al., 1989).

Barucci et al. (1989) analysed asteroids with known rotation periods by means of Fourier analysis of all lightcurves published before 1985. They used a sample of about one hundred "best observed" objects to discuss their shape distribution. The sample was subdivided in four categories: 32 % of the selected asteroids have been classified as more or less elongated ellipsoids, 25 % irregular, 23 % spheroids and 20 % as objects probably characterized by albedo features.

2.3 Pole Direction

The methods for pole determination can be summarized as follows: photometric astrometry (Taylor, 1979), amplitude-aspect and/or magnitude-aspect relation (Zappalà et al., 1983), speckle interferometry (Drummond et al., 1985), methods combining epochs of extrema and amplitude-aspect relations (Magnusson, 1983; for a review of pole determination methods, see Magnusson, 1989). The method based on the lightcurve amplitude as a function of the position of the asteroid in its orbit (amplitude-magnitude method) has already given spin axis directions for about 30 asteroids with a good accuracy. The amplitude-magnitude (AM) method can be applied when complete lightcurves, obtained during at least 3 different oppositions, are available. In this way we can obtain a rough estimate of the pole direction: the larger the number of lightcurves at different ecliptic longitudes, the more accurate is the determination. Astrometric and speckle interferometry methods are in principle more accurate, but are also more difficult to apply and have resulted in about ten additional determinations up to now.

The number of asteroids with known pole directions is too small to perform conclusive statistical studies, but from a preliminary analysis there seems to be a distinct bimodality in the pole direction distribution (Fig. 3).

The determination of the pole direction of asteroids should lead to a better understanding of the role of the colli-

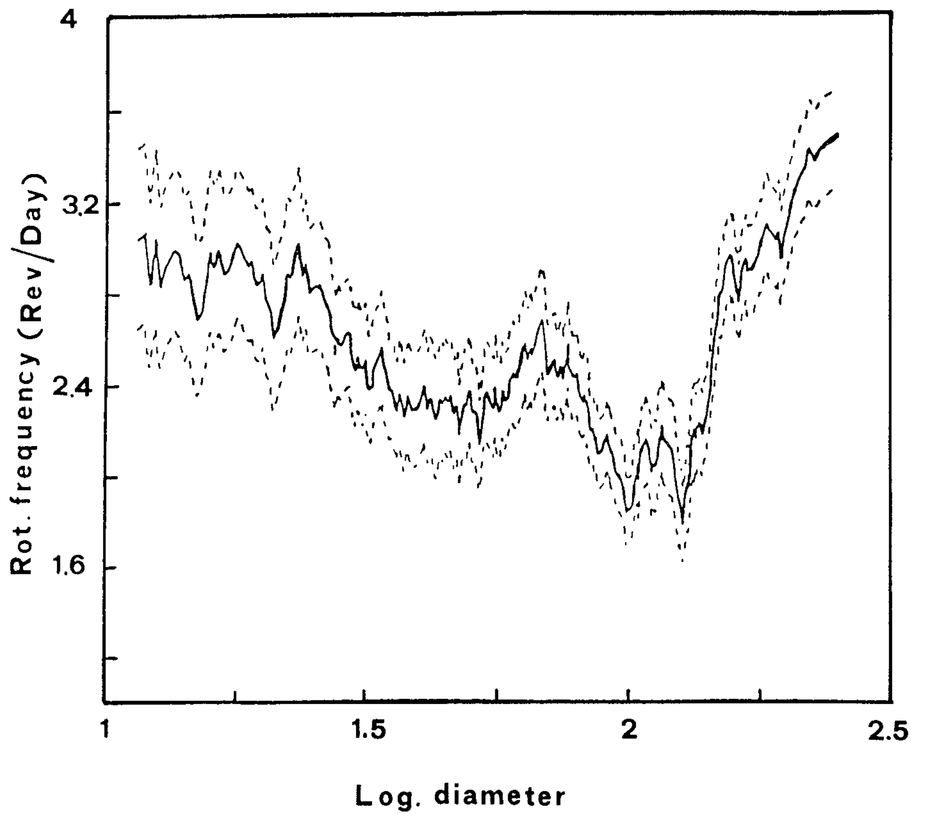

Figure 2: *Plot of rotational frequency versus log diameter for all asteroids with known rotational period, excluding the planet-crossing objects and members of the major dynamical families. The "running-box" contained n = N/10 asteroids (N is the total number of objects in the sample) and was stepped through the population one asteroid at a time over the entire diameter range. One-sigma uncertainties are shown above and below the mean (dashed lines).*

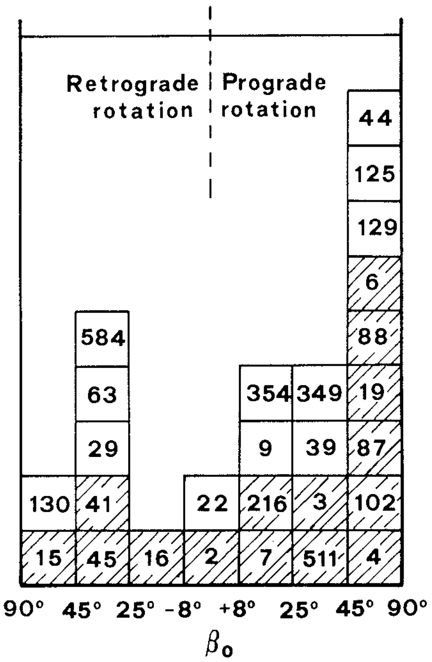

Figure 3: *Distribution of pole ecliptic latitudes (β_o) for 27 main-belt asteroids whose pole direction has been determined with good accuracy. Shaded boxes indicate objects larger than 200 km.*

sional processes in shaping the physical characters of the population: a distribution with a preferential orientation would record the initial state of the axis inclinations, while a random distribution would indicate a complete reorientation of the spin axes due to the prevalence of collisions.

2.4 Taxonomy and Composition

The chemical composition of asteroids is of great interest because the different mineralogical assemblages may give interesting clues to the understanding of the primordial processes that took place in the solar nebula and during the early stages of the accretion. The principal source of information about composition comes from spectral analysis of reflected sunlight, although other techniques like polarimetry, radiometry and radar have yielded important contributions.

Many taxonomic classifications have been developed in the last decade (for a review, see Tholen, 1989), aiming at understanding some of the physical and compositional properties of the asteroid population. Two recent works are based on multivariate statistical analysis of asteroids for which a homogeneous set of spectrophotometric data, from ultraviolet to infrared, are available (Tholen, 1984; Barucci et al., 1987, which complete the data set with IRAS albedos). Barucci et al. analysed 442 asteroids and in this sample identified nine major taxonomic types, namely B, E, G, C, M, D, S, V, A and interpreted the links between the classes in terms of genetic trends. To understand better their possible evolution, they compared the asteroid classes with some meteorite samples.

In Figure 4 the classes are reported in a diagram where four trends are distinguished by the arrows that leave from D asteroids (dark objects with very red spectra suggesting the presence of low-temperature organic compounds and typical of the Trojan group) supposed to be primitive objects which have undergone little or nor heating. Each arrow goes towards an "end class" and its direction generally indicates a decrease in heliocentric distance.

The first trend links together the D cluster with the B one, including the C class (probably similar in composition to carbonaceous chondritic meteorites). This trend might be interpreted in terms of volatile content reduction. According to this interpretation, the class D samples are richer in volatiles, while the B's are the poorest due to higher formation temperature.

The second trend, connecting the D to the E class through G and M, may be interpreted as a progressive evolution of the solar nebula condensates (D) towards the enstatite achondrites (E) through an ultraprimitive, high-carbon, low-metamorphic-grade C-type mineral assemblage (G) and a reduction (transition metal free) silicate similar to the enstatite chondrites (M). The E asteroids may be composed by the silicates formed when enstatite chondritic bodies (M) were differentiated.

The third and fourth trends ending at V and A classes, respectively, seem to represent lines of increasing differentiation, starting from the undifferentiated material D. The third trend connects the D class (through a subunit of S asteroids) to the V class whose end members are covered by basaltic material (4 Vesta) and olivine/pyroxene rich materials (349 Dembowska and 192 Nausikaa). The fourth trend connects the primitive D cluster to the A unit and contains most of the S asteroids, whose spectra show bands due to silicates. The A asteroids show in their spectrum an olivine absorption band that may represent the signature of mantle material of a differentiated body.

In the asteroid population a great diversity of albedos is present. Accounting for the observational biases, about 75% of the asteroids are found to be very dark, with average albedo of about 0.3 (D, C, and B types), another group of objects presents an albedo of about 0.15 (S, E, M, and V types), few asteroids lie in between, while some bright bodies have albedos up to 0.40 or more.

Very interesting is the fact that, in general, different taxonomic types are located at different heliocentric distances. This compositional gradient is interpreted as a "portrait" of the solar nebula matter, which condensed into

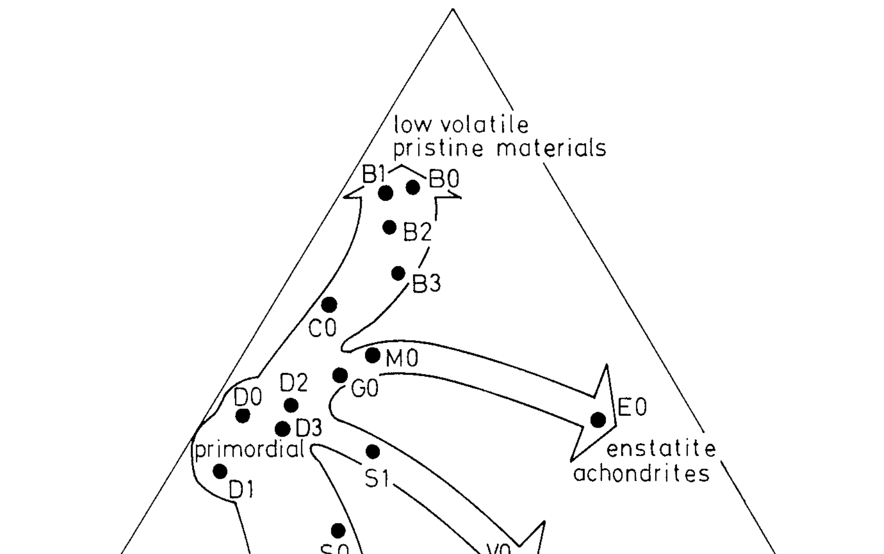

Figure 4: *Diagram showing the evolutionary compositional trends of asteroids. The arrows leave from D-type objects supposed to be primitive objects which have undergone little or no heating.*

solid grains first, then formed the planetesimals. This variation in the composition was clearly related to the temperature decrease with solar distance. It is also noteworthy that asteroids belonging to primitive taxonomic types (corresponding to least metamorphosed material) are present in the outer belt regions.

3. Collisional Evolution and Asteroid Families

During the last decade, several theoretical and statistical articles (Binzel et al., 1988; Davis et al., 1985, 1989; Farinella et al., 1981, 1982; Zappalà et al., 1984) have shown how important the mutual collisions among asteroids are for outlining the evolution of the main belt following the primordial phases. The outcome of collisions are strongly size-dependent, in the sense that the largest asteroids (D $\geqslant$ 300 km) appear not to have been strongly affected by catastrophic events. In the case of intermediate size objects (100 $\leqslant$ D $\leqslant$ 300) the largest probable impact energy is close to the limits for disruption and for the transfer of a quasi-critical amount of angular momentum. In this size range is possible the formation of binaries, triaxial equilibrium ellipsoids, and dynamical families, i.e. groupings of asteroids significantly clustered in three orbital elements: semi-major axis (a), eccentricity (e), and inclination (i). In this case, self-gravitation prevents complete dispersion of the target asteroid fragments. In fact, most of the dispersed mass is reaccumulated by the mutual gravitational attraction of the fragments and the resulting objects may be described as a "rubble-pile" or a mega-regolith asteroid (Farinella et al., 1981), in which rocks from crust, mantle, and core of a differentiated body have been jumbled up, thus forming a group of bodies dominated by self-gravitation. Such bodies, owing to their state of fragmentation, will relax in hydrostatic equilibrium figures consistent with their angular momentum.

If, following the catastrophic impact, the initial velocity of some fragments exceed the escape velocity of the target, a few of them may escape, reaching heliocentric orbits with elements very close to those of the larger remnant. In this case an "asymmetric dynamical family" is formed by a large object and a small tail of a few minor asteroids. When the target mass decreases, the probability to obtain dynamical families increases significantly. In this case the families are not only formed by the asymmetric tail of high-velocity fragments originating close to the impact point, but they are formed by bodies ejected in all the directions. We have then the so-called "dispersed families". Finally, the smaller asteroids can be considered single fragments generated by catastrophic impact disruptions. Their shapes can be irregular since they are dominated by solid-state forces and their rotation rate is connected with the partitioning of the angular momentum which occurred during the catastrophic break-up of their parent body (Chapman et al., 1989).

In conclusion, we can state that most of the asteroid population can be considered to have been influenced by collisional processes and the observed differentiations may be due to the physical differences of the target asteroids, to their varying size and also to the various impact velocities and geometry. However, this description involves some important points which must still be better understood, either because of the presence of very severe selection effects in the available ground-based observing data, or because of discrepancies between the real cases and the results of laboratory hypervelocity impact experiments (Fujiwara et al., 1989).

4. Some Open Problems

4.1 Apollo-Amor-Atens (AAA) Asteroids

Among the small bodies of the solar system, the Earth (Apollo and Atens) and Mars (Amor) crossing asteroid population may contain a small but meaningful sample of primitive objects. The AAA asteroids are generally quite small, of the order of 5 km in diameter. The growing number of discoveries of such objects with large aphelion distances and carbonaceous-type reflectance spectra strongly suggests that part of them may derive from cometary sources (are they extinct comets?). On the other hand, the AAA with typical diameters of about 1 km could correspond to a low-mass tail of the distribution of fragments produced in catastrophic collisions which occurred in the main belt and then injected into the inner regions of the solar system.

Comparison of the properties of comets and asteroids of the AAA class is complicated by the fact that not much is known about the rotational properties and spectra of these asteroids. Photometry and spectroscopy of these objects is difficult since they are faint and in favourable positions for observation during a short time only. Some interesting insight into their origins could be obtained through a more complete rotational period data set. Up to now only for about 20 % of the known AAA population (about 90 objects out of an estimated population of about 1000) have complete lightcurves been obtained.

4.2 Distant Asteroids

Owing to their great heliocentric distance and their corresponding faintness, few observational data have been obtained on Trojans (a ~5.2 AU) and on outer-main-belt asteroids belonging to the Hilda (a ~4 AU) and Cybele (a ~3.4 AU) groups. These objects are of considerable interest because of recent discoveries, both about their composition and the possible evolution of their orbits (Milani and Nobili, 1985). Distant asteroids predominantly belong to taxonomic classes characterized by low albedo and red colours, and observational results from comet nuclei suggest a similiar classification (Hartmann et al., 1987). To explain the dark, reddish surfaces of D-type asteroids, which make up more than half of Trojans, Gradie and Veverka (1980) suggested that the spectra of D-type material can be reproduced by a mixture of silicates with carbonaceous compounds, even more primitive than those found in the carbonaceous chondrites. This is in agreement with current condensation theories about the formation of the solar system and is supported by the spectral studies of Vilas and Smith (1985), who observed an increasing reddening of asteroid spectra with heliocentric distance among the Cybele, Hilda and Trojan groups of asteroids. Eight-colour photometry of the outer jovian satellites, at the same heliocentric distance as the Trojans, shows however that these objects are probably mostly C-type. This "mixing" of C and D types – D in the Trojan groups and C in the jovian system – poses a complication for the standard formation model of direct correlation between asteroid composition and heliocentric distance. The identification of D material in the saturnian satellite system and the similarity between the continuum spectra of some old comets to those of D objects suggest that the Trojans may not have formed at their present location, but further out, and could be related to comets.

For the above-mentioned reasons, observations of distant groups of asteroids (a $\geqslant$ 3.25 AU) should be considered highly important, offering the possibility to collect data on objects quite different from the main-belt population.

5. Conclusions

Space missions devoted to the exploration of small bodies of the solar system, such as Vesta, CRAF and Rosetta, or including asteroid fly-by, as Galileo and Cassini, will give a wealth of high-quality data on the asteroid population. Not a single close-up picture of a minor planet is yet available, but more information on asteroid rotations, shapes, poles and compositional types would provide interesting clues in understanding the role of collisions in producing the observed asteroid belt and more in general in the evolution of the solar system. Moreover, the data coming from *in situ* measurements will be detailed enough to clarify the nature and the interrelationships between small bodies populations, if any. Are some of the Earth-crossing asteroids nuclei of dead comets? Are the meteorites fragments of asteroids disrupted by mutual collisions, or are they the smallest size tail of the asteroidal size distribution? Are double or multiple systems present among asteroids?

In order to give an answer to these and other questions, while we wait for the results of the space missions, it is necessary to improve the number and quality of data on asteroids: unbiased and detailed Earth-based surveys, ISO orbiting observatory results and Space Telescope inputs will be the main sources of the future data. Embedded in the asteroid belt may be the clues that will help us to unravel the structure of the early solar system, to learn about the planetesimals and their evolution, and to fathom the mechanism by which planet-building was halted in this part of our planetary system.

Thanks to the ESO facilities, especially in the last five years, a lot of data, both physical and astrometric, were obtained on asteroids. Nevertheless, many unsolved problems still remain open and among these the most intriguing are: (i) the knowledge of physical characteristics and origin of outer main belt and AAA asteroids, (ii) the collisional evolution of main belt objects and the related origin of dynamical families.

So far ESO has provided to the European asteroidal community small telescopes only (ESO 50-cm and 1-m, Bochum 61-cm, Danish 1.52-m and GPO). But in order to deepen our knowledge on asteroids and to solve, at least partially, the above-mentioned problems, the availability of larger instruments will be necessary, in particular, for photometric, polarimetric and spectroscopic observations.

Asteroids may be "small" and "near", nevertheless they deserve being investigated by means of large telescopes!

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The Dust Tail of Comet Wilson 1987 VII

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1. Introduction

Several photographic plates, both in red and blue light, were obtained by means of the ESO Schmidt camera to study the dust and plasma tails of Comet Wilson 1987 VII. All these plates were calibrated by means of calibration wedges and therefore are suitable for a quantitative analysis of the dust and ion tails. The pass-band of the emulsion-filter combination of red plates is from 630 to 700 nm, close to the R photometric system. We used plates 6810, 6829 and 6842 to study the dust environment of C/1987 VII before perihelion by means of the inverse numerical method which was successfully tested on C/1973 XII and C/1962 III (Fulle, 1989).

This model considers $\mathbf{N}_t \times \mathbf{N}_\mu \times \mathbf{N}_s$ sample dust grains, where $\mathbf{N}_t$ is the number of samples in the time interval of dust ejection, $\mathbf{N}_\mu$ is the number of samples in the sizes, and $\mathbf{N}_s$ is the number of grains of a fixed size uniformly distributed on a dust shell. It considers different ejection geometries for each of which the ejection of dust is restricted to a cone of half width w with its symmetry axis pointing toward the Sun. The position of each grain at the observation is derived from its keplerian motion, then projected into the photographic plane coordinate system, so as to obtain the model distribution of the scattered light from the tail and the related kernel matrix A. The solutions are given by the minimization of the functional $[AF-I]^2 + \beta[BF]^2$, where A is the kernel matrix, I is the data vector containing the dust tail

Plate	Time	UT	r	Δ	α	Exp.	Emulsion	S_{10B}	R_{sky}
6810	Mar	27366	1.26	1.42	43°	20	098+RG630	–	–
6829	Apr	2368	1.23	1.24	48°	30	098+RG630	915 ± 15	20.38 ± 0.02
6842	Apr	7348	1.22	1.09	51°	30	098+RG630	750 ± 20	20.60 ± 0.04

TABLE 1: Photographic data. Plate, serial number of the photographic plate. Time UT, time of mid-exposure. r, Δ, Sun-Comet and Earth-Comet distances (AU). α, Phase angle. Exp., exposure time (minutes). Emulsion, emulsion and filter combination. S_{10B}, sky background surface light intensity expressed in number of 10 R-magnitude stars per square degree. R_{sky}, sky background R-magnitude arcsec^{-2}.

surface light intensities of the N_k images sampled in $N_N \times N_M$ points, B is a regularizing matrix weighted by β, and F is the solution vector sampled in $N_t \times N_\mu$ values, from which the dust number and mass loss rates and the time dependent and time averaged size distributions can be directly computed. Contrarily, the dust ejection velocity v(t) is required for the computation of the matrix A, so that it must be determined by means of a trial and error procedure. The regularizing weight β tunes the constraints to our ill-posed problem: when β increases, the instability of F decreases, but also the quality of the fit to the data. Therefore, the most probable dust velocity v(t) is defined as the function giving a stable and positive vector F for a regularizing weight β as small as possible.

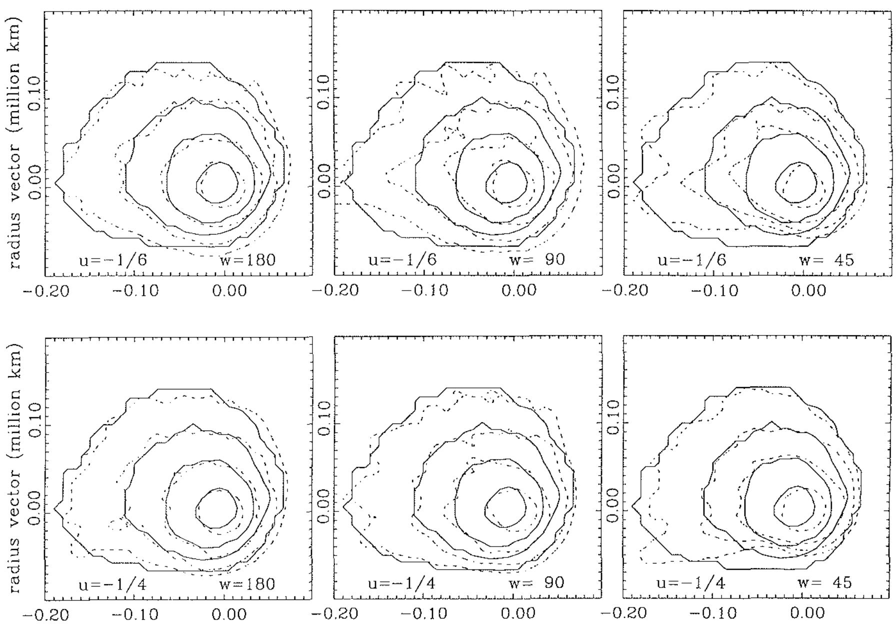

Figure 1: *Isophotes of the dust tail from image 6810 for the intensity levels 1.6, 2.4, 3.8 and 8.7 expressed in sky surface intensity units. The distances along the axes are expressed in 10^6 km units. Continuous lines: observed isophotes. Dashed lines: computed isophotes. w is the anisotropy parameter. u = δ log v(t, d)/δ log d (Table 2).*

2. Data Reduction

The plates were digitized adopting square scanning windows of 50 μm^2 and the photographic densities were transformed into intensity by means of the related calibration wedges. To perform the absolute calibration of the images, we selected three photometric fields from the first edition of the new Guide Star Photometric Catalogue (GSPC-I, Lasker, Sturch et al., 1988). Such fields were digitized by means of a square scanning window of 20 μm^2 and were linearized by means of the same calibration wedges used for the comet images. For each GSPC-I star of visual magnitude V, we obtained the red magnitude R following Johnson (1966) and measured the integrated intensity over a sky area covering the whole star trail and over a same area of sky background near the star trail, obtaining the sky background surface light intensity S_{10B} expressed in number of 10 R-magnitude stars per square degree (Table 1). The very small errors affecting the sky intensities refer to the fits to the measured star intensities, and not to systematic errors, which may well be larger and may have been introduced by the reciprocity effect of the plates (the exposure times of the stars and of the comet were obviously different, since the comet image is fixed, whereas the stars are trailed) and by the differences between our pass-band and the R photometric system.

3. Results

In Figure 1 we show the comparison between input image 6810 and the reconstruction of the same image by means of the solution F, which allows to test the accuracy of the solution itself and the stability of our constrained inverse problem. In Table 2 we show the parameters associated with the application of our method to the images of C/1987VII. For each parameter combination, we tested the number of trial velocity functions v(t) given in the table. The solutions concerning the dust ejection velocities, the range of diameters of the considered sample grains, the dust loss rates and the power index of the time-dependent size distribution are shown in

u	w	$\mathbf{N_s}$	$\mathbf{N_\mu}$	$\mathbf{N_t}$	N_t	N_μ	N_k	N_M	N_N	T	**M**	S
−1/6	180°	284	100	100	20	10	3	30	30	8	4.4	○
−1/6	90°	143	100	100	20	10	3	30	30	27	3.3	□
−1/6	45°	382	100	100	20	10	3	30	30	10	1.9	△
−1/4	180°	284	100	100	20	10	3	30	30	12	6.0	+
−1/4	90°	143	100	100	20	10	3	30	30	9	5.4	×
−1/4	45°	382	100	100	20	10	3	30	30	31	2.7	⁎

TABLE 2: *Parameters of the model of Comet Wilson. u = δ log v(t, d)/δ log d. w, half width of the dust ejection cone: isotropic ejection (half width of π), hemispherical ejections (half width of π/2), and strongly anisotropic ejections (half width of π/4). $\mathbf{N_s}$, $\mathbf{N_\mu}$, $\mathbf{N_t}$, dust samples on a dust shell, in the modified size and in time. N_t, N_μ, samples of the solution in time and in the modified size. N_M, N_N, samples of the N_k source images in the M and N directions. T, number of test functions v(t). **M**, total ejected dust mass (10^{14} grams) for Ap(α) = 0.02. S, symbol in Fig. 2.*

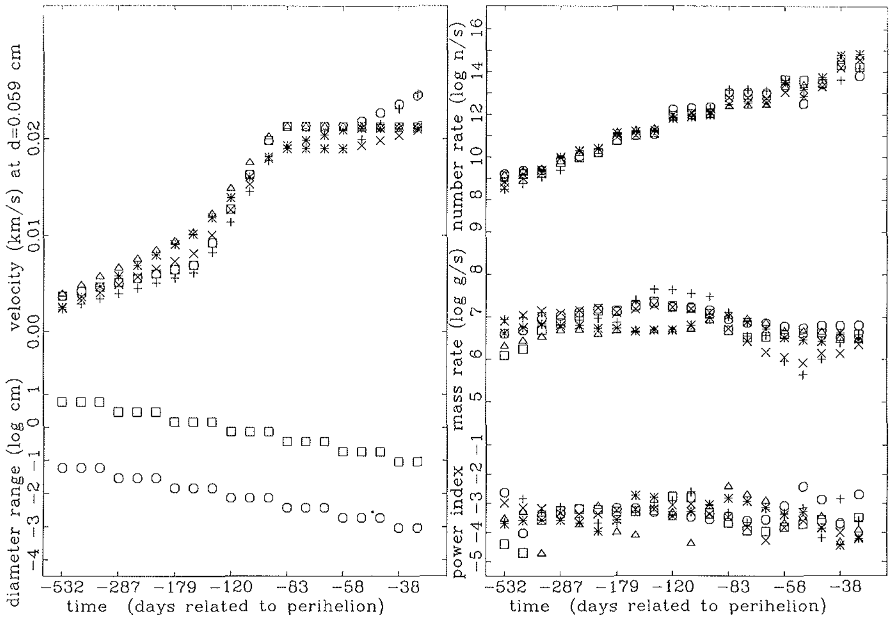

Figure 2: *Dust environment of Comet Wilson 1987 VII assuming the albedo Ap(α) = 0.02: the dust loss rates (depending inversely on Ap(α)), the dust ejection velocity, the power index of the time-dependent size distribution and the diameter interval to which all the solutions are related. The symbols are related to Table 2. The time sampling steps correspond to true anomaly steps of 5°.*

Figure 2. The dust loss rates were computed adopting the albedo Ap(α) = 0.02 (Hanner and Newburn, 1989, $43° < \alpha < 51°$, phase angle α in Table 1). The slow increase of the dust number loss rate is mostly due to the decreasing size interval which was considered. The mass loss rate related to isotropic dust ejections shows a wide maximum at $t \approx -120$ (days related to perihelion), that is at $r \approx 2.4$ AU, whereas the mass loss rate related to strongly anisotropic ejections is about constant. Large uncertainties of the loss rates are due to the poorly known albedo of large grains. The loss rates shown in Figure 2 are inversely proportional to the assumed value of Ap(α). The uncertainties of the dust bulk density are much less important. In fact the mass loss rate computed by means of dust tail analysis is independent of the dust density (Fulle, 1989), whereas the number loss rate is directly proportional to the square of dust density. For plates exposed to the red pass-band, the contamination by plasma (H_2O^+) is a concern along the prolonged radius vector. This is reflected in the residual instability of the solutions for $t > -60$, which explains the large dispersion of the mass loss rates and of the power index of the size distribution. However, plasma contamination to the left-hand side of the tails is very improbable, so that for $t < -60$ the solutions should be free of significant errors.

We find that C/1987 VII produced more than 10^6 g s^{-1} of dust during two years before perihelion, and this may be related to its high relative luminosity at the first observations. Our results suggest that the mass loss rate does not increase close to perihelion, in agreement with the results of Hanner and Newburn (1989). The power index of the size distribution shows small variations. We find that its value is higher than −4, and this implies the release of very large grains. This fact is confirmed by the time averaged size distribution, characterized by the very high power index of -3.0 ± 0.1. These results show that the dust loss of Comet Wilson 1987 VII was already significant at $r \approx 7$ AU, a Sun-Comet distance even larger than that observed for Comet Kohoutek ($r \approx 5$ AU). At these distances the gas production should be dominated by CO_2, and we observe also a maximum of the dust mass loss rate and a fast increase of the dust ejection velocity when the sublimation of H_2O becomes efficient.

Acknowledgements

The plates were digitized by means of the PDS of the Padova Astronomical Observatory. The calculations were performed on the Apollo computers of Astronet Trieste centre. The diagrams were generated using Astronet AGL standard graphics. We thank P. D. Usher for useful discussions concerning the plate calibration. This work has been supported by a PSN/CNR grant to Prof. C. Barbieri.

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Chiron's Blue Coma

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The Most Distant Minor Planet Known

Among the nearly 4500 minor planets which have been numbered until now, (2060) Chiron is by far the most distant and certainly one of the most unusual. It moves in a rather eccentric orbit between the giant planets Saturn and Uranus and each revolution lasts just over 50 years.

Chiron was discovered in late 1977 by Charles Kowal of the Palomar Observatory. He found a slow-moving, 18-mag object on plates taken with the Palomar Schmidt telescope and within a few weeks, enough positions had been measured to compute a preliminary orbit. It was later identified on other photographic plates dating back to 1895, and soon the unique nature of Chiron was firmly established.

At the time of its discovery, Chiron was classified as a "minor planet", and it was obvious that it must be a very large one, in order to be so bright at this large distance. Depending on its ability to reflect sunlight (albedo), the diameter was estimated as somewhere between 100 and 250 kilometres. Kowal and other minor planet specialists felt that Chiron might be the first of a new family of minor planets, and it was inofficially de-

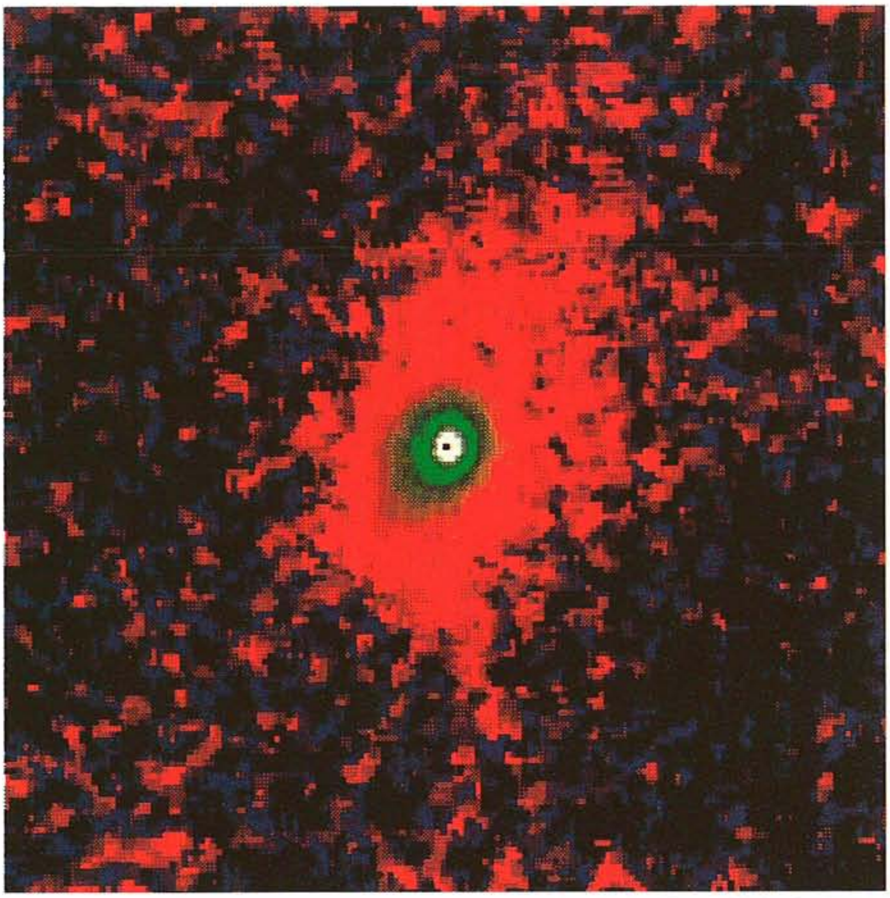


Figure 1: *False-colour reproduction of Chiron's coma in visual light. The field size is 70 × 70 arcsec; North is up and East is to the left. Galactic stars have been removed from this picture, which is a composite of 20 frames with a total integration time of 107 min. The outer isophote corresponds to a surface brightness of V ~ 27.5 mag/arcsec².*

cided that other members of this class would also be given the names of mythological Centaurs, half man and half animal like Chiron itself. However, despite various search programmes, notably by Kowal at Palomar, no other members of this class have been found until now, though some of the minor satellites of the outer planets may possibly be captured objects which are physically similar to Chiron.

Minor Planet Or Comet?

The first years after its discovery, Chiron looked like a minor planet and behaved like one. Slowly moving towards its perihelion – which it will reach in early February 1996 at heliocentric distance 8.48 A. U. – its brightness rose gradually through the 1980's, exactly at the rate predicted for an inert body which shines by sunlight reflected from its surface.

However, in 1988 a strange phenomenon was observed. Comparing with observations from 1986, D.J. Tholen and his collaborators working at the NASA Infrared Telescope on Hawaii noticed that Chiron suddenly appeared to have brightened by several tenths of a magnitude more than predicted (IAU Circular 4554). This trend continued and by the end of 1988, Chiron was almost one magnitude brighter than it ought to be.

No other minor planet is known to have behaved this way and the idea was soon put forward that Chiron is actually a comet, i.e. a body consisting of ice and dust, rather than a minor planet of solid rock. Some astronomers also thought of a minor planet whose surface is partly covered by a layer of ices. A natural explanation of the brightness increase would then be the sublimation of ices from the surface, leading to the creation of a "coma", a surrounding cloud of icy particles and possibly also some dust, released in the same process. Such a coma would reflect the sunlight and thereby increase the observed brightness.

A coma was indeed seen around Chiron in early 1989 by Karen Mees and Michael Belton with the Kitt Peak 4-m telescope (IAU Circular 4770). It had the form of a 5-arcsecond, very weak extension towards southeast. Further observations with the Canada-France Hawaii Telescope by Karen Mees in early 1990 confirmed the presence of this coma (IAU Circular 4947).

Observations at ESO

During four nights in late February this year, I had the opportunity to observe Chiron and its newly discovered coma with a CCD camera at the Danish 1.5-m telescope at La Silla. My main object of study, Comet Halley, was too low in the sky to be observed during the first hour of the night and I therefore took this opportunity to point the telescope towards Chiron. Both objects have a very faint coma around a point-like light source, but while the magnitude of Halley's nucleus was only 24–25, Chiron was much brighter, about 16.5 in the visual range. It was therefore necessary to restrict the integration time to a few minutes in order to avoid overexposing (saturating) the image of Chiron with the undesirable side-effects of photometric non-linearity and column "bleeding".

In all, about three hours of exposure was obtained in the two standard colours B (4000–4800 Å) and V (5000–5800 Å). The cleaning of the frames was quite laborious, in particular because of the rather large number of pixels with deviating sensitivity on this CCD chip (ESO No. 15). The sky background was also rather "dirty": there were comparatively strong interference fringes in the V-band, most likely due to the exceptional strength of the atmospheric oxygen line at 5577 Å, at this time near solar maximum activity.

Adding the frames in the V-band produced the false-colour image reproduced here (Fig. 1), for the first time showing the large extent of the Chiron coma and allowing a more detailed study of its morphology. We see first of all that it is elliptically shaped with the major axis in NW-SE direction. It can be followed to about 20 arcseconds from Chiron where the surface brightness is near 28 mag/arcsecond², i.e. ~7 mag, or over 600 times, fainter than the sky emission in the V-band (Fig. 2).

What may be even more interesting is that the colour of this coma is rather blue; at 5 arcseconds from the centre, (B–V) = 0.3 ± 0.1, and it looks as if the coma reddens slightly outwards to about (B–V) = 0.45 at 12 arcsecond distance. The colour of Chiron itself was measured in the early 1980's as (B–V) = 0.70 ± 0.02, i.e. near the solar value (0.65) and typical for a C-type minor planet (see also the article by di Martino et al. in this *Messenger* issue on page 50). Thus the coma is significantly bluer than the surface of Chiron. This is also confirmed, when the predicted light contribution from Chiron itself is subtracted from the central condensation of

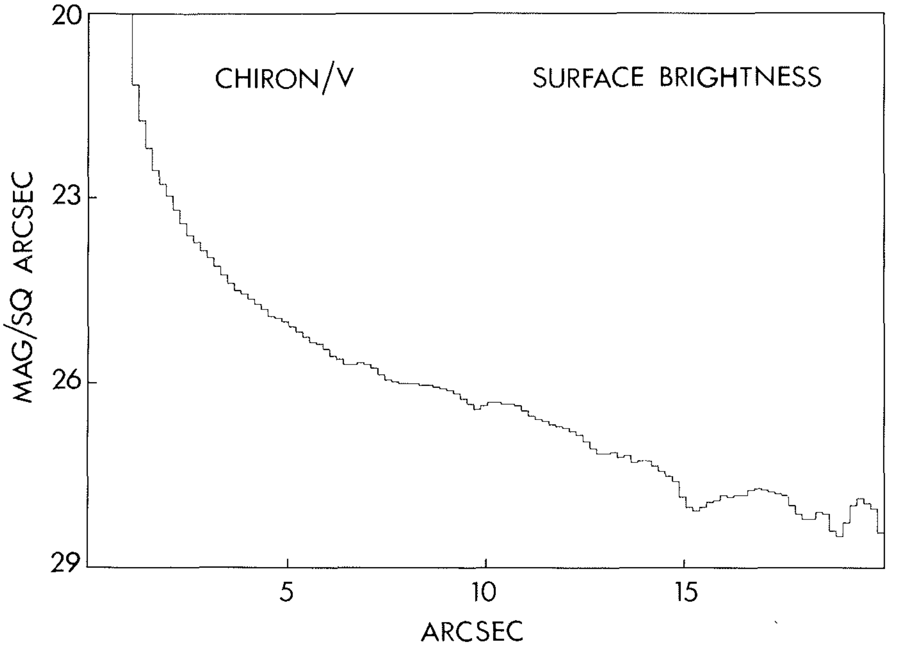


Figure 2: *Mean radial luminosity profile in V of Chiron's coma, after subtraction of the contribution from Chiron itself. The abscissa indicates the distance from the centre in arcseconds (1 arcsec = 7680 kilometres projected); the ordinate is the surface brightness in magnitudes per square arcsecond. The corresponding sky background emission is ~21 mag/arcsec^2.*

light; the remaining image, which is presumably that of the coma cloud immediately surrounding Chiron, is also blue, (B–V) = 0.4 ± 0.1.

The blue colour of the coma is most likely due to the scattering of the sunlight by small particles. The possible reddening outward can be explained by the destruction of the smallest particles as they drift away from Chiron, so that the relative content of larger particles increases outwards. This is therefore in general agreement with the idea that the coma is caused by the sublimation of ices on the surface, a process that apparently started when Chiron's inward-bound orbital motion brought it within ~12 A.U. of the Sun.

It will of course be necessary to study the coma in more wavebands before it is possible to be more specific about the nature of these particles, their size distribution, chemical composition and density.

Chiron's Rotation

By careful measurement of the brightness of the central condensation, it was possible to confirm the light variation noted earlier by Bus et al. (*Icarus,* **77,** p. 223, 1989), on the basis of CCD measurements in 1986 and 1988. Thanks to the longer time interval, the period of this variation, i.e. the rotation period, can now be estimated with higher accuracy: P = 5.91783 ± 0.00005 hours.

The absence of any significant, night-to-night changes in the coma structure, and the lack of evidence of "jets" or "spirals" in the coma, leaves the impression that the evaporation occurs over a larger surface area, rather than from isolated vents, like those detected on the nucleus of Halley. It can be seen (Fig. 1) that the innermost part of the coma is somewhat asymmetrically placed with respect to the nucleus. The direction of this elongation does not coincide with the direction to the Sun or the direction of orbital motion, both vectors being near West (p.a. = 269° and 289°, respectively).

It is in principle possible that this asymmetry is connected to the direction of the rotation axis, the projection of which might be perpendicular to the direction of inner coma elongation. Since the evaporation from the surface is likely to be strongest during the "Chiron afternoon", just after the most intensive solar heating at "noon", the direction of rotation would appear to be from NW to SE, as seen projected onto the sky. However, it should not be forgotten that even the inner coma features are still at several arcseconds' distance from the centre of light, i.e. more than 20,000 km from Chiron's surface. They may therefore not be directly connected to phenomena on or just above the surface.

Future Investigations

Details about these new observations of Chiron's coma will be reported in a forthcoming paper in *Astronomy & Astrophysics.* They pose a number of interesting questions which can only be answered by a more detailed investigation. For instance, it would be most desirable to perform photometry of the coma in other wavebands, also in the infrared region. Apparently, no gaseous emissions lines have been observed so far in the spectrum of Chiron, but it may well be that a gaseous component of the coma can be detected at a later time.

There is little doubt that Chiron will be a popular target for solar system astronomers during the coming years.

New Communication Link Between Garching and La Silla

A. WALLANDER, ESO

1. Introduction

In the beginning of February a new permanent communication link between ESO Headquarters and observatory came into operation. This new 64 kbps digital link will, among other things, become the backbone for remote control of the New Technology Telescope (NTT). Although the physical distance between Garching and La Silla will always be the same, the new communication link will make the logical distance between people working in Europe and South America smaller. It will contribute to a higher level of integration of the organization increasing the productivity both in technological and scientific areas.

La Silla and Garching have already been linked on a permanent basis for several years via an analogue leased line. Astronomers and engineers have become accustomed to call up colleagues on the other side of the Atlantic

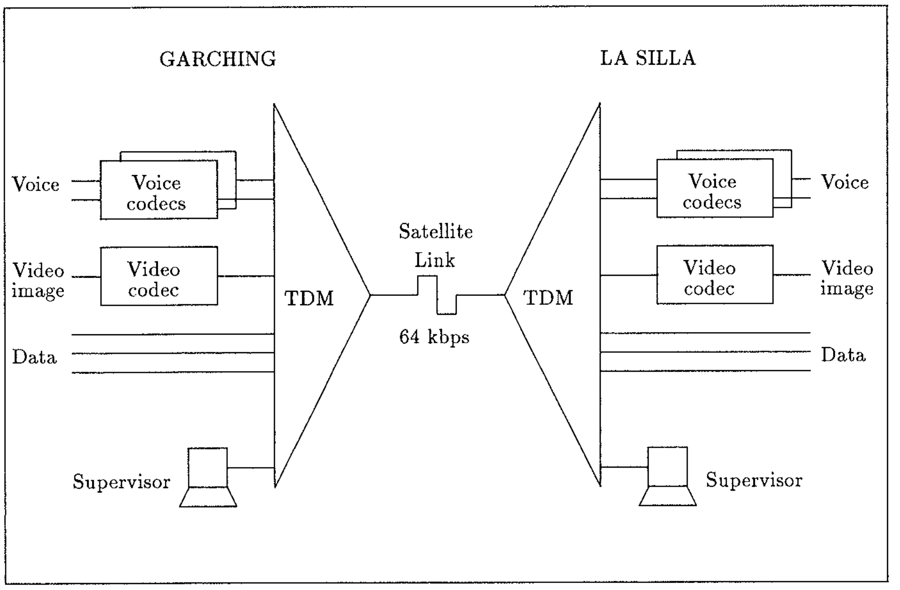


Figure 1: *System Architecture.*

simply by dialling a special prefix number. Many e-mail and fax messages pass over this line every day. The CAT or the 2.2-m telescope is controlled from Europe around 12 nights every month using this leased line. The new link will, at least for the time being, be a complement to these well-established communication facilities. In both cases the links are leased from the German and Chilean PTT's and are using Intelsat communication satellites.

When discussing long-distance communication links, the most important characteristic is bandwidth or the amount of information which can be transmitted within a time interval. The new digital link has five times higher capacity to transmit raw digital information compared to the analogue link and this to only a 20 % higher cost. This is in line with the present trend in international communication tariffing, whereby cost for higher bandwidth digital leased lines is decreasing.

2. Requirements

Experience with the existing remote observing facilities for the CAT and 2.2-m telescopes has shown the need to integrate voice, data and video image communications. Experience with the analogue line has also shown the importance of allowing more general communications during day time when no telescopes are remotely controlled. In fact, one could argue that this second point is more important since remote control always will be used less than 50 % of the time.

Integration of voice, data and video image communication has been a hot topic for some time and is addressed in developments like ISDN (Integrated Services Digital Network), fast packet switching and other upcoming technologies. To appreciate the difficulties, one has to consider the different characteristics of these types of communications. Voice and video are analogue in nature and need to be digitized before using digital transmission media. Voice and video transmissions are also sensitive to delays, but not so fuzzy about correctness. The opposite is true for digital data transmission, where correctness is a must, but reasonable delays are not so critical.

The combined requirements of remote control and general communications call for a system which integrates data, voice and video image communications. Depending on the type of operation, different users should be given access to the link. The system should be "future compatible" in the sense that new users should be easy to integrate, hardware should support a future higher bandwidth link and the system should be adaptable to new technologies. High reliability and availability should be guaranteed through the use of redundancy and powerful monitoring and diagnostic functions. These are very ambitious requirements, especially when considering the limited trunk bandwidth of 64 kbps.

3. System Architecture

The integration of many users has been implemented by means of time division multiplexing (TDM). This technique allows the 64 kbps trunk to be spit up into smaller bandwidth user channels. The method of time division implies that the sum of the user channels bandwidth is less than the trunk bandwidth. The allocation of bandwidth is done from a supervisor terminal connected to the TDM microprocessor. Reconfiguration can be made from one side on-line or via preprogrammed configurations activated at a defined time of day. The system is extendable in the sense that new users (input channels) can be added by plug in modules. The system also allows for

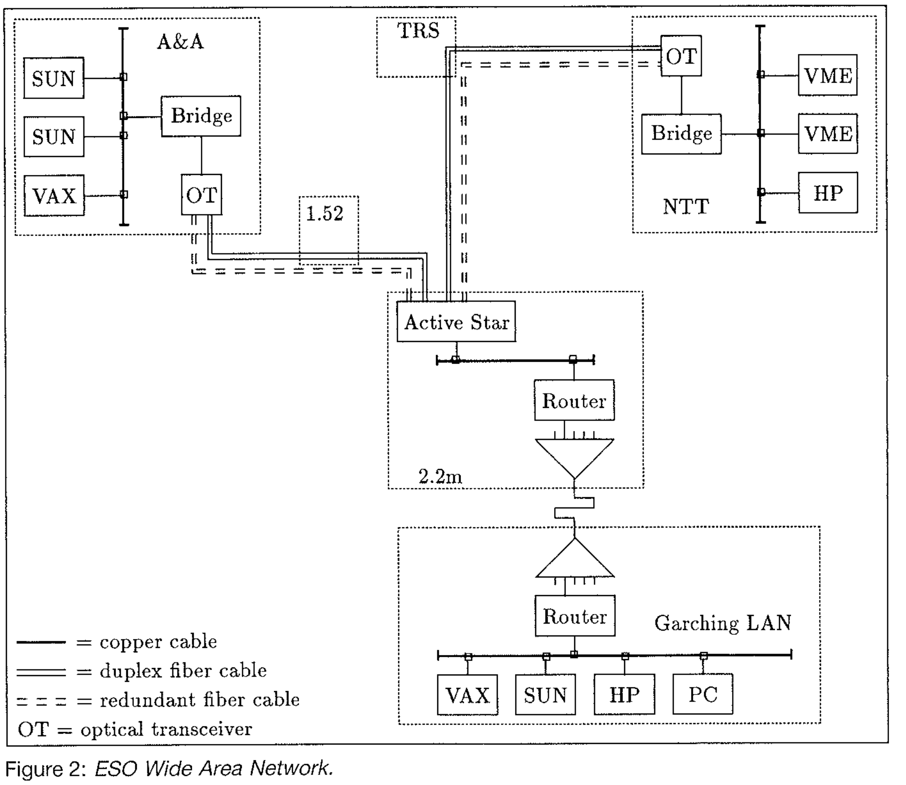


Figure 2: *ESO Wide Area Network.*

duplication of processor board and power supply with automatic switch over in case of failure.

3.1 Voice

To implement meaningful voice connections the telephone exchanges (PBX) at the two sites need to be connected. This allows any extension at one site calling any extension at the other site using a prefix number to access the external tie line. That is exactly the way the present tie line connection over the analogue link works. However, in order to interface to the TDM, the analogue voice signal first has to be digitized.

The common method to digitize voice is to use pulse code modulation (PCM). The analogue voice signal is sampled at 8000 Hz and each sample is coded in 8 bits, thus a bandwidth of 64 kbps is required for one voice channel. Using this method obviously is bad economy over the new digital link (remember the initial statement that this line has five times the capacity of the analogue line). Different types of delta modulation, where the difference between two samples is coded instead of the absolute value, improves the situation and the same voice quality can be obtained using only 32 kbps. By using parametric coding instead of waveform coding, it is possible to further decrease the necessary bandwidth. This requires more complex signal processing and powerful hardware. With present technology it is not possible to maintain the same voice quality when going down in bandwidth. The main question is if the voice quality using this method is acceptable to the users.

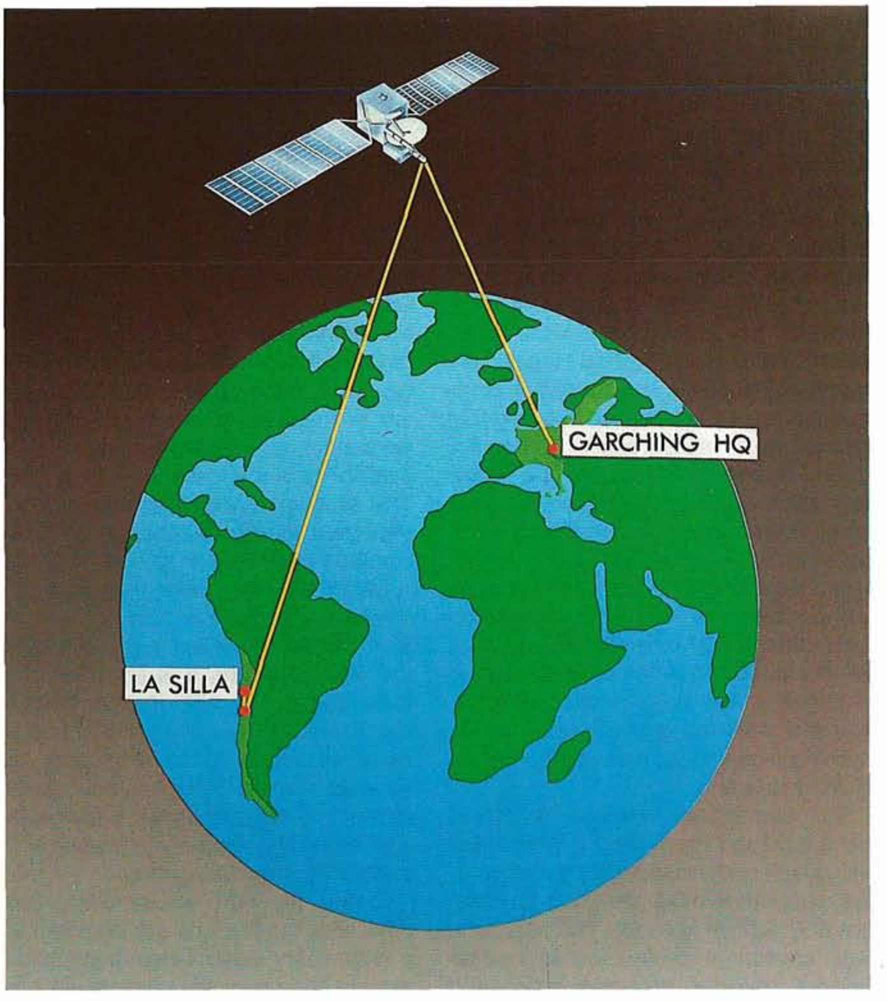
Considering the need to share the 64 kbps trunk between many users, it was decided to install state-of-the-art voice codecs using only 2.4 kbps. Thus it would in principle be possible to have 26 such voice channels over the link. Two such voice codecs have been installed and were taken into operation after some initial interfacing problems to the PBX at La Silla were rapidly solved by Luis Aguila. The initial experience is that these voice channels are useable. Improvements are still possible as some problems have been identified and should be solved in the near future. This system may anyway be complemented with one higher quality, higher bandwidth voice channel. Use of such a voice channel will however penalize other users and cannot be available all the time.

3.2 Video Images

The remote observing astronomer needs to have access to TV pictures available locally at the telescopes. Therefore, a video image transmission system is required. One could also think of other applications, like some type of video conferencing, where such a system could be useful. However, when considering the enormous information contents in a video signal and the limited bandwidth available, compromises have to be sought. A full motion digitized video signal requires a bandwidth of hundreds of Mbps. By using advanced compression algorithms it is however possible to transmit lower resolution and/or lower refresh rate video images over a lower bandwidth channel.

A slow scan television system has been chosen that operates either in high resolution (576 * 720 pixels) or medium resolution (356 * 576 pixels) mode. In high resolution mode a video image is captured and digitized using 16 bits per pixel into 6 Mbits of data. These data are compressed 20 times before transmission. Because compression, transmission and decompression are carried out in parallel and communication overhead is minimized, the resulting frame refresh rate over a 48 kbps channel is about 10 seconds. In medium resolution mode this figure is reduced by a factor of two.

A preliminary version of this system was used during the NTT inauguration to transmit images from the auditorium in Garching to La Silla.



3.3 Data

Data communication for remote control of the CAT and the 2.2-m telescope is based on a point-to-point connection between the remote control computer and the instrument computer. A similar connection has been implemented to the NTT control computer over the new digital link. However, this type of connection does not solve the need for generality and connections to other computers. At La Silla there had been the wish for some time to build up a network connecting the various telescopes and the general off-line computers.

In close collaboration with people from La Silla, in particular Gaetano Andreoni, a design was worked out to start implementing such a network. The initial need was to connect the local area network (LAN) of the NTT and the general computer LAN in the administration building with the LAN in Garching. Due to the distances at La Silla (diameter over 3000 m) the transmission media had to be optical fiber. Use of fiber optics also have the advantage of removing problems of earthing and risk for damage to equipments during lightning. It was decided to start implementing a fiber optic Ethernet backbone network. A backbone network only carries traffic between the connected LAN's, while local traffic is contained locally by means of bridges. The hardware components were chosen in such a way that new points of interest easily can be integrated by pulling new fibers and installing new modules. For reliability reasons all fiber links are duplicated with automatic switch over in case of fiber breakage. Fibers have also been chosen to be compatible with the next generation LAN called FDDI (fiber distributed data interface) running at ten times the speed (100 Mbps). The delicate work of installing and terminating fibers, using fusion splicing technology, was carried out by Rolando Medina.

The connection between the backbone LAN and the TDM is implemented using high performance OSI level 3 routers, supporting multi protocols (at present only TCP/IP is used). This approach was chosen in preference to remote bridges because of performance and security reasons. A router gives better performance for short interactive messages and provides much more powerful security and diagnostic facilities.

This implementation gives full connectivity between all computers connected to a LAN in Garching or La Silla using TCP/IP protocol. The routers allow access control on a host basis as well as definition of type of access, e.g. a host may be allowed to send e-mail, but not allowed to do a remote login (TELNET, rlogin).

4. Experience After the First Months of Operation

In the long term, the availability of the link will become crucial. More and more users will realize the advantage using this communication facility and take for granted it should be available. At ESO we can build in redundancy and recovery procedures in our equipment, but we cannot do anything to guarantee the availability of the leased line from PTTs. This situation is very frustrating and it is important to collect statistics and analyse fault conditions in this initial phase.

During the first weeks of operation the downtime of the link was about 30%. This terrible figure has improved, but at the time of writing it is still 10%. It is clear that this is still unacceptable for the future, but hopefully the improving trend will continue. Good working relationship with the PTTs has been established and by identifying weak points and improving recovery procedures the availability should improve.

During the NTT inauguration, three days after the link was available to ESO, a preliminary video image transmission system and one voice channel were operational. The point-to-point connection to the NTT computer has been used extensively for software upgrades and troubleshooting during the last months. It will continue to prove to be an important tool during the integration of EMMI and later IRSPEC software. The fiber optic backbone network at La Silla was taken into operation and connected to Garching LAN without problems. At the time of writing it is normal to see at least one user from La Silla logged in on the main VAX in Garching. It is fair to say that this proves the usefulness of this connection and it is expected that the use of this facility will increase drastically in the near future.

It should be noted that all installations at La Silla have been carried out by local staff, in particular Gaetano Andreoni, Rolando Medina and Luis Aguila. During the commissioning phase the communication system itself was used extensively. Troubleshooting and integration of new components are facilitated by an intense communication via e-mail, file transfers and telephone conversations.

5. Future Developments

During the coming year work will concentrate on implementing remote control of the NTT. This application will have priority and other users will have to accept this.

However, it is expected that other applications will also gain in importance. For example, it is already planned to extend the backbone network at La Silla to other telescopes. New local applications over the backbone network are expected, e.g. data sharing between telescopes, archiving, centralized information accessible on-line from the telescopes (STARCAT, seeing measurements), etc.

Software development and maintenance, not only for telescope and instrument control, but also for MIDAS and other applications, will become much easier.

In the long run, the experience and know-how gained by using this communication link will be an asset for the VLT project.

Atmospheric Extinction at La Silla from September to December 1989

N. CRAMER, Observatoire de Genève, Sauverny, Switzerland

Since November 1975, the Geneva Observatory photometry group has been systematically carrying out measurements in the Geneva 7-colour system at La Silla. Special care has been taken to ensure the conservation of the passbands and of the reduction procedures over the period of almost 30 years that the system has been in use. This guarantees the long-term homogeneity of the data recorded.

The M+D technique developed by F. Rufener (see for example a description in *Astron. Astrophys.* **165,** 275–286, 1986; or in *IAU Symp.* **111,** 253–268, 1985) allows the measurement of the atmospheric extinction coefficients and their evolution with time over the duration of a night of observations. Our observers usually apply that technique when the meteorological conditions are judged to remain good during the whole night; otherwise, the observations are carried out at a constant air mass and the reduction is generally done by using the mean extinction values of the site. During the reductions of M + D observations, however, the instantaneous monochromatic extinction coefficients corresponding to the mean wavelength of each filter are computed throughout the duration of the night.

Over the years, we have frequently

been asked by visiting astronomers at La Silla for these values obtained at given dates. We have therefore offered the editor of the *Messenger* to publish some of these results in the journal. This should be possible, provided that not too much of the valuable space is taken up by these data.

In the table, which covers the last four months of 1989, we present in a concise form the mean monochromatic extinction coefficients measured by the M + D technique during the nights beginning on the given dates. The second line gives the standard deviations over the variations of each value during the night and provides a rough estimate of the stability of the transparency at that time.

The frequency of M + D nights in this table is fairly irregular; no attempt should, however, be made to interpolate between non-consecutive nights. Readers who would like to have more detailed information (for example evolution of the extinction over a given night) may contact me.

Monochromatic Extinction Coefficients (La Silla) at 3464, 4015, 4227, 4476, 5395, 5488, 5807 Å.

Date	U σU	B1 σB1	B σB	B2 σB2	V1 σV1	V σV	G σG
8. 9.89	.6013	.3083	.2509	.2064	.1327	.1355	.1230
	.0063	.0064	.0057	.0051	.0058	.0046	.0063
14. 9.89	.5909	.2988	.2415	.2032	.1301	.1303	.1186
	.0058	.0064	.0060	.0059	.0064	.0049	.0079
15. 9.89	.5967	.3095	.2476	.2102	.1338	.1345	.1237
	.0075	.0052	.0047	.0050	.0050	.0041	.0067
16. 9.89	.5921	.3007	.2456	.2047	.1272	.1323	.1233
	.0053	.0059	.0058	.0057	.0059	.0048	.0069
18. 9.89	.6102	.3168	.2513	.2102	.1373	.1362	.1230
	.0047	.0045	.0043	.0058	.0048	.0031	.0081
23. 9.89	.6258	.3302	.2666	.2260	.1458	.1493	.1310
	.0060	.0046	.0046	.0040	.0036	.0022	.0058
24. 9.89	.5893	.3026	.2454	.2060	.1269	.1274	.1180
	.0048	.0032	.0027	.0025	.0033	.0010	.0046
25. 9.89	.6092	.3191	.2624	.2230	.1386	.1414	.1278
	.0057	.0056	.0058	.0057	.0059	.0050	.0070
27. 9.89	.6194	.3267	.2674	.2225	.1437	.1458	.1321
	.0083	.0050	.0062	.0036	.0040	.0030	.0047
20.10.89	.5958	.3084	.2515	.2107	.1317	.1339	.1227
	.0038	.0037	.0027	.0030	.0019	.0015	.0028
19.11.89	.6173	.3257	.2663	.2171	.1351	.1337	.1231
	.0047	.0038	.0036	.0040	.0025	.0020	.0036
20.11.89	.6208	.3279	.2690	.2238	.1362	.1368	.1217
	.0036	.0028	.0026	.0026	.0026	.0020	.0041
30.11.89	.5993	.3116	.2507	.2015	.1368	.1287	.1192
	.0048	.0028	.0029	.0020	.0025	.0009	.0018
2.12.89	.6061	.3135	.2547	.2131	.1289	.1251	.1184
	.0068	.0045	.0050	.0047	.0028	.0027	.0031
3.12.89	.5993	.3030	.2468	.2029	.1255	.1197	.1127
	.0075	.0039	.0035	.0035	.0033	.0024	.0032
6.12.89	.5980	.3124	.2491	.2088	.1315	.1265	.1181
	.0034	.0027	.0024	.0027	.0030	.0024	.0032
11.12.89	.6945	.3179	.2578	.2111	.1334	.1293	.1209
	.0070	.0047	.0042	.0050	.0041	.0039	.0042
21.12.89	.6803	.3777	.3145	.2683	.1697	.1723	.1554
	.0095	.0092	.0090	.0094	.0091	.0088	.0096
22.12.89	.6424	.3484	.2868	.2391	.1535	.1505	.1405
	.0138	.0111	.0106	.0098	.0090	.0088	.0096
23.12.89	.6273	.3389	.2770	.2310	.1425	.1436	.1257
	.0084	.0073	.0062	.0061	.0059	.0057	.0073
24.12.89	.7070	.4019	.3353	.2877	.1901	.1905	.1735
	.0051	.0042	.0041	.0036	.0036	.0032	.0035
30.12.89	.7231	.4134	.3446	.2993	.2008	.1969	.1792
	.0109	.0079	.0075	.0072	.0068	.0066	.0077
31.12.89	.7005	.3957	.3270	.2823	.1862	.1845	.1698
	.0143	.0126	.0116	.0113	.0111	.0108	.0116

MIDAS Memo

ESO Image Processing Group

1. Application Developments

Some improvements have been added to the applications related to spectroscopy especially in the LONG SLIT context. All the commands related to the context ECHELLE have now been ported from the old MIDAS into the 90 MAY release and tested on CASPEC data.

A number of irritating problems still exist in many applications either due to unclear documentation or errors in routines often caused by the conversion to portable code. A major effort on validating the basic MIDAS commands will be made in the remaining part of the year. Functionality and documentation of each command will be tested by ESO in-house astronomers in order to find and correct inconsistencies and errors. It is expected that this concentrated effort will significantly improve and stabilize MIDAS and establish a very reliable MIDAS core. The next high priority will be a major revision of the standard reduction packages for major ESO instruments.

2. MIDAS Courses

The first MIDAS course was held in early April on installation of MIDAS on VAX/VMS systems. Eleven system managers from different European MIDAS sites participated in the course which took one day and a half. In addition to a detailed discussion of an actual installation on a VAXstation 3100 with VMS 5.3 and DECwindows, the course covered the general structure of MIDAS and special costumization of the system for individual user sites.

Similar courses for both VAX/VMS and UNIX installations will be made in the future depending on demand. The Image Processing Group also plan to make courses in programming in MIDAS both using the control language and coded application programmes. Such programming courses would however only be started at the very end of 1990 or beginning of 1991.

3. New Positions

Two additional short-term positions (with durations of up to two years) have been allocated to the MIDAS group. They will be used mainly for improvements and developments of new application programmes in MIDAS. Not only will this make it possible to have new algorithms and applications included into MIDAS after a period of limited improvements in this area, it will also at longer term spread the detailed knowledge of MIDAS in the community when people in these positions return to their home institutes.

In addition to these positions, it will be possible to invite people who have made interesting algorithms and programmes to ESO for an implementation of them into the MIDAS environment.

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 eight countries: Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands, Sweden and Switzerland. It operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where fourteen optical telescopes with diameters up to 3.6 m and a 15-m submillimetre radio telescope (SEST) are now in operation. The 3.5-m New Technology Telescope (NTT) has recently become operational and a giant telescope (VLT = Very Large Telescope), consisting of four 8-m telescopes (equivalent aperture = 16 m) is under construction. Eight hundred scientists make proposals each year for the use of the telescopes at La Silla. The ESO Headquarters are located in Garching, near Munich, FRG. It is the scientific-technical and administrative centre of ESO, where technical development programmes are carried out to provide the La Silla observatory with the most advanced instruments. There are also extensive facilities which enable the scientists to analyze their data. In Europe ESO employs about 150 international Staff members, Fellows and Associates; at La Silla about 40 and, in addition, 150 local Staff members.

The ESO MESSENGER is published four times a year: normally in March, June, September and December. ESO also publishes Conference Proceedings, Preprints, Technical Notes and other material connected to its activities. Press Releases inform the media about particular events. For further information, contact the ESO Information Service at the following address:

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

ISSN 0722-6691

People interested in contributing and/or making new applications to MIDAS may contact the IPG with detailed descriptions.

4. Data Analysis Workshop

The annual ESO/ST-ECF Data Analysis Workshop took place from April 24 to 26. It consisted of a scientific meeting of one day and a half centred on reduction software for spectroscopic data followed by one day with user meetings for both MIDAS and ST-ECF. Approximately 90 people participated in the meeting where more than 20 papers and posters were presented. Proceedings of the scientific session will be published during the course of this year.

Next year the Data Analysis Workshop is expected to take place in April with the emphasis on reduction procedures for direct imaging data.

5. MIDAS Hot-Line Service

The following MIDAS support services can be used to obtain help quickly when problems arise:

- EARN: MIDAS@DGAESO51
- SPAN: ESOMC1::MIDAS
- FAX.: +49-89-3202362, attn.: MIDAS HOT-LINE
- Tlx.: 528 282 22 eso d, attn.: MIDAS HOT-LINE
- Tel.: +49-89-32006-456

Users are also invited to send us any suggestions or comments. Although we do provide a telephone service, we ask users to use it only in urgent cases. To make it easier for us to process the requests properly, we ask you, when possible, to submit requests in written form through either electronic networks, telefax or telex.

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