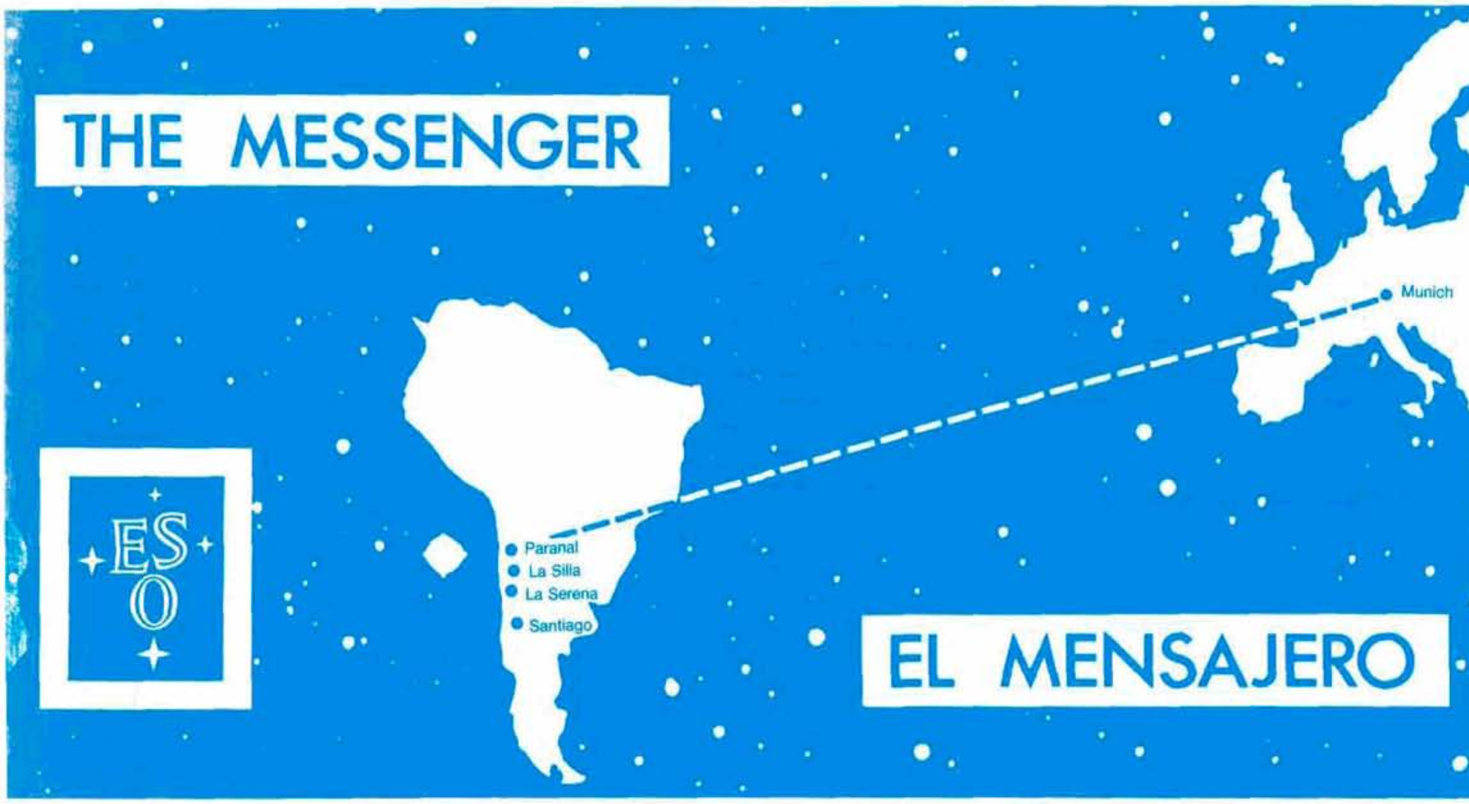

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TELESCOPES AND INSTRUMENTATION

Re-invigorating the NTT as a New Technology Telescope

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1. Introduction

The justification for building the 3.5-m New Technology Telescope (NTT) went well beyond a mere quantitative increase of the research opportunities for the community after Italy and Switzerland had joined ESO (Woltjer 1980): with the NTT ESO wished to demonstrate the feasibility of the technological and conceptual breakthrough which is required for the transition from conventional telescopes to the Very Large Telescope (VLT).

Already at first light, the viability of the active optics principle and the benefits of a very compact enclosure were impressively confirmed (Wilson 1989) with an effective image quality of 0.33 arcsec. Comparison with the measurements obtained with the differential seeing monitor (DIMM2) on Vizcachas and La Silla shows that the probability of encountering such a good seeing even in the excellent period of 1988–1990 hardly ever exceeded 1–2 % for one-hour averages (Sarazin 1990). The fact that the exposure times at first light were as short as 10 seconds (the instrument rotator was not yet installed) may, therefore, have helped (see also Sarazin 1989). The legend insists in any case that the coincidence of first light and the birthday of the father of the active optics concept, Ray Wilson, were instrumental for this early success.

It has often been remarked that after the commissioning period the NTT apparently never fully repeated this early performance. However, it deserves to be noted that since the end of 1990 the average seeing recorded with DIMM2 kept deteriorating until the middle of 1993 when a dramatic improvement started which still has not levelled off. The most recent data are fully comparable to the 1988–1990 La Silla data and the Paranal measurements (Sarazin 1994). A more detailed report by Marc Sarazin will appear in one of the next issues of *The Messenger.* Moreover, preliminary analysis of 6 nights worth of SUSI observations in January 1994, during which DIMM2 measured an external seeing (averaged over the actual duration of the individual SUSI exposures) of 0.65 ± 0.15 arcsec, indicates that, if anything, the NTT delivered slightly better images than predicted by DIMM2.

In any event, sufficiently many excellent observations have been obtained to raise the expectations of the observers community substantially above the traditional level. However, these hopes have often been disappointed. The specific technical reasons are diverse but often relate to a lack of reliability. With the benefit of hindsight it is obvious today that the commissioning period of the NTT was too short and the complexity of the NTT and its subsystem requires more attention than corresponds merely to the increase in the number of telescopes on La Silla from eleven to a dozen.

The potential of the NTT in preparing for the VLT was re-emphasized by J. Schwarz acting as an external adviser to the Director General. Starting in August

1993, ESO has therefore performed a detailed analysis of the present status of the NTT and various strategies for improvements. With the support and encouragement of the ESO committees concerned and the Working Group Scientific Priorities for La Silla, a concerted effort is now being undertaken to more fully exploit the potential of the NTT, in the interest of its own users as well as of the VLT.

2. Objectives of an NTT Upgrade

From the above it is clear that the most immediate objective must be to stabilize the performance of the NTT. Once this has been achieved, better use should be made of the NTT in preparation for the operation of the VLT. This leads to objectives Nos. 2 and 3, namely to test the VLT control system and to verify the VLT operations concept with the NTT.

To achieve the latter goals will not be inexpensive. However, any major teething problems of the VLT will be incomparably more costly. The NTT is the only ESO telescope which provides a suitable platform for these efforts because in many ways it anticipates VLT concepts. Although implemention of the VLT control system and operations plan are not required from a pure NTT point of view, it is also clear that the *technical realization* of the present NTT control system does not offer much of an option for gradual but significant upgrades. For instance, only complete replacement of the computer hardware will give the NTT a new long-term perspective.

These three objectives will be pursued in three consecutive phases, I, II, and III.

3. Phases of Implementation

For technical reasons, we start with the constraints which define the beginning of Phase II: Much of the justification for upgrading the NTT control system derives from the expected feedback into the version to be installed at the VLT. Accordingly, the NTT schedule is determined by the timetable for the VLT. Since the very first tests of the Telescope Control Software (TCS) should not be performed with a working telescope, the original plan foresaw that the NTT would only see build 2 of the TCS after build 1 had been thoroughly checked during the European assembly of the mechanical structure of unit telescope No. 1 in Milan. With the current schedule of the Milan tests extending into the first weeks of 1996 but no delay of first light, a more closely interleaved test pattern will have to be developed. The other constraint is that in order to have a profound effect on the actual VLT control system, full installation at the NTT should commence as early as possible. This will be in late 1995.

This Phase II will last for about one year. During the first 4–6 months, the installation will not permit any scientific observations to be carried out. Thereafter the plan foresees observations only in service mode. The reason is that only in this way the two most important and apparently conflicting requirements can be fulfilled, namely to let the telescope produce scientific data at the earliest possible moment and to give the technical staff enough time to fully re-commission the telescope. Service observers can more easily cope with temporary, varying, and not properly documented operating conditions. Flexible scheduling can ensure that always the technically most suitable and scientifically most important programmes are carried out.

Phase I covers the period between now and the beginning of Phase II. Its primary aim is to stabilize the performance of the NTT. This will mainly be done by introducing a more rigorous operations model of which more continuous monitoring of the performance will be an essential component. Substantial technical improvements are not foreseen. The emphasis will rather be on robustness, transparency, and quantitative accountability. If major repairs should turn out to be necessary, it will in each case be considered whether a lower loss of scientific opportunities would be incurred if they were postponed until Phase II. Clearly, the preparation of Phase II will continue throughout Phase I.

Finally, during Phase III also the model for operation of the VLT, which is due for the Council meeting in December 1994, should be tested and implemented step by step. In this way, the NTT would logically become the first (fifth) unit telescope of the VLT and serve as a training camp for future VLT operations staff.

Phases I and II have been approved, their implementation is proceeding. The discussion of Phase III will continue during the preparation of the VLT Operations Plan.

4. Operational Framework

The main organizational measure taken has been to form a dedicated team which as of April 1, 1994 will be put in full charge of the NTT. On La Silla, this NTT Team currently comprises 2 software (PG and RR), 1 electronics (DG), and 1 opto-mechanics (PhG) engineer as well as two astronomers (GM [also in charge of the local coordination on La Silla] and JS). In Garching, we so far have one software engineer (AW – software group leader and responsible for re-building the control system) and one astronomer (DB – project scientist). Vacancy notices for one astronomer each at both sites have been published recently. This edition of the *Messenger* contains the advertisement of a postdoctoral fellowship position which is to be re-filled at the end of 1994. Furthermore, two more software engineers will be recruited soon. They will start their work in Garching but for Phase II be transferred to La Silla together with one current member of the VLT software group (Eric Allaert) in Garching. Finally, the NTT Team is happy that Edmond Giraud was given the opportunity to take leave of absence from the Observatoire de Marseille in order to return to La Silla for one year and to work with the NTT Team until its scientific staff complement is complete.

In the domains of electronics, optomechanics, and all stand-by services, the above staffing level is far from being sufficient to fully cover all needs of the NTT. Areas such as detectors, maintenance and construction, wiring, mechanics, computer networking, etc., are not all represented on the NTT Team. This is intended because full self-sufficiency would not be a realistic goal if the costs are to be affordable. Therefore, the daily operation of the NTT will continue to rely strongly on the support by numerous technical services on La Silla, especially the Operations Group. On a rotating schedule, a fixed number of night assistants will maintain close familiarity with the NTT. In fact, the most fundamental role of the NTT Team will be to integrate a broad spectrum of expertise into one joint concept. Especially a stronger unification of ESO-Chile and ESO-Garching will have pilot character also for the operation of the VLT. The adequacy of the present staffing level will be carefully monitored and, if necessary, further adjusted.

At least during Phase I, the operation of IRSPEC will not be directly integrated into the responsibilities of the NTT Team. Since the Infrared Team is generally acknowledged to function well, the chances of immediate improvements are relatively minor whereas the price to be paid for a discontinuity could be non-negligible. This approach is, of course, made easier by the present lack of concrete plans for the upgrading (or even replacement) of IRSPEC.

5. Phase I

Because of their large number, we here only list the activities in extreme brevity:

- Perform complete inventory of problems and assets.
- Complete commissioning of NTT and accomplish transfer of know-how to NTT Team.
- Establish automatic operation of active optics system as default mode; use ~80 % of light from guide star for continuous image analysis and telescope autofocussing. Make results more transparent to users; perform automatic quality and plausibility checks.
- In addition to the La Silla site monitor, use second guide probe in Nasmyth station B (EMMI) for independent image quality monitoring and log NTT dome-internal meteorological conditions. The objective is to identify constellations which significantly compromise the effective NTT seeing. A prototype of the VLT enclosure management system will be developed for the NTT in order to actively minimize degradation.
- Introduce regular computer system management (back-ups, configuration control, load monitoring, etc.).
- Perhaps upgrade CPU of NTT computer; if unavoidable ditto for operating system. The present workload of the NTT computer runs at a level of 60 % of its capacity. This had for a while been seen as one possible reason for one or more of the real-time nodes (altitude axis, azimuth axis, and rotator) often losing synchronization with the NTT computer. However, since September 1993 this problem has essentially vanished after a bug in the recovery procedure had been discovered and corrected.
- Install computer-based problem tracking system for reporting by users, follow-up by maintenance staff, and as a source of recipes for future problems.
- Document limiting performance of telescope and instruments. Comparison of actual results against these reference data will enable early recognition of anomalies as well as false alarms.
- Regularly measure key characteristics of CCD detectors. Provide simplified procedures for checks also by Visiting Astronomers.
- Step by step identify areas in need of regular preventive maintenance.
- Introduce procedures towards putting soft- and hardware under strict configuration control.
- Continue remote observing from Garching at modest level. This observing mode had a rather successful start (Balestra et al. 1993, Baade et al. 1993) and helps to ensure that the La Silla and Garching view of the NTT do not differ too widely.
- Extend scope of MIDAS Data Organizer (Péron et al. 1994) to on-line applications in order to better support quality and health control of the data sets acquired.
- Enhance logging of normal telescope and instrument operations and unscheduled events. Use database to measure observing efficiency (later compare old and new control system), identify possible problems and design solutions (for instance, in this way it was possible to track down a problem in the CCD control software which caused the data to be irrecoverably lost in about 1 % of all cases).
- Perform several field tests of individual components of the new control system (cf. Section Phase II). Always return to the old system.

Most of these activities have started already. Obviously, they rely in many cases strongly on the active support and always on the advice by other groups and individuals at ESO.

To the above list have to be added the routine support of Visiting Astronomers and the rescue operations in case of acute failures. However, the ultimate purpose of many of the above measures is, of course, that the incidence and severity of open crises and latent problems will be significantly reduced.

6. Phase II

That the development of a new NTT control system according to VLT standards is at all affordable, is due to the modular, layered design of the VLT control software which foresees a large proportion of shared general-purpose utilities (Raffi 1992). The NTT effort, then, largely consists in implementing the NTT specific applications on top of this lower-level software. This work has been broken down into 19 work components. They closely follow the schedule according to which the VLT software is being written. At the same time, they provide an additional corset to that timetable and via the advanced field tests with the NTT some extra check points of the products.

The first two tests are scheduled for May 1994 and comprise the VLT Local Control Unit (LCU) common software in stand-alone mode and embedded in the VLT Central Control Software (CCS), respectively. The first application will be the control of the NTT building. In an analogous fashion, work component 3 concerns secondary and tertiary mirror of the NTT and will take place in September 1994.

One of the central work components is the control software for EMMI. It plays a special role also in so far as it has been taken on by the software group on La Silla (G. Andreoni and R. Schmutzer are the main responsibles). This is a major contribution of the La Silla observatory in the framework of the VLT development. Although the support of the latter cannot at this phase be a significant responsibility of La Silla, it is, on the other hand, important that all ESO sites share the same technical and methodological standards. The EMMI work component is one more step into this direction.

Important improvements are expected from the replacement of the present ISIT TV cameras with VLT technical CCD cameras. Higher effective sensitivity, lesser non-linearity, larger dynamical range come to everyone's mind as expected improvements. At least as important appears the resulting potential of direct digital signal processing which will, for instance by automatic detection and centring of sources, noticeably enhance the observing efficiency. – Also for the scientific CCDs the VLT CCD controller will be installed, thereby closing another feedback loop prior to the coming into operation of the VLT.

For selected observing modes, for instance imaging through frequently used standard filters and grism spectroscopy, an attempt will be made to maintain an on-line calibration database. When combined with automatic data reduction procedures, this will permit the observer a quantitative on-line quality control. Although publication quality may in many cases not be a realistic goal, quick and objective quality control is of course of central importance in the case of service observing.

A close companion of service observing will be flexible scheduling. Among the possible operations features which are presently being discussed for the VLT, this couple clearly marks the most drastic deviation from the standard model for ground-based observatories. Promising though the theoretical supporting arguments are, without prior practical tests and quantitative measurements the risk might be inacceptably high.

7. Phase III

The goal of this period will be to establish a VLT-like operations model. In order to obtain meaningful feedback about it, it is essential that the hardware be changed as little as possible. For a while this may also mean the exclusion of visitor instruments. Possible upgrades which might be considered include the replacement of IRSPEC (which was first installed at the 3.6-m telescope in 1985 and in Phase III will be rather old given the ever accelerating evolution of IR technology) and rapid tip-tilt guiding with M3 (the solution adopted by the Italian *Galileo* project) or M2 (borrowing from the VLT concept). Because of its commonalities with the VLT, the NTT will provide optimal training opportunities for VLT operations staff both in Chile and Garching.

8. Further Sources of Information

The NTT Team will do its best to support prospective applicants for observing time as well as actual observers. An updated edition of the EMMI/SUSI users manual will soon become available. A completely revised version is expected to be ready for the September 30 deadline and will be accessible also via anonymous ftp and under Xmosaic.

News too recent for inclusion into manuals will be posted in the dedicated usenet newsgroup eso.visas.ntt. For the time being, this newsgroup will not be exported. Any messages posted can be read only after logging onto the captive account esobb on the ESO computers (Internet address: 134.171.8.4 or ftphost.hq.eso.org).

Any additional inquiries we request to be e-mailed to the dedicated NTT account (ntt@eso.org on Internet or ESO::NTT on SPAN). Because of the time difference between Europe and Chile, the weekly shift system on La Silla, and duty trips or vacations of NTT staff members, this is the only way to make sure that your message is processed within the shortest possible time.

9. User Feedback

No service can be expected to be better than the constructive criticism which it receives from its clients. The NTT is no exception. On the contrary, the numerous tasks and the very tight schedule will make insufficiencies unavoidable. Your echo will help us to find the right course more quickly. Every NTT Team member will be happy to accept and forward your suggestions. A particularly efficient communication channel may again be the NTT account mentioned before.

10. Acknowledgements

As explained above, the NTT Team has been conceived such as to always depend substantially on the support by numerous staff in virtually all departments at both La Silla and Garching. We have already seen many examples that this concept is a viable one and take this opportunity to cordially thank all colleagues concerned. Since all of them are already very busy with the VLT or the other La Silla telescopes, their help should not be taken for granted. The expectation is that eventually the experience with the NTT will pay some dividend also for them.

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VLT Main Structure Design

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The main structure of the VLT unit telescope has been completely designed in almost all its details, and performances have been calculated in as much detail as possible, to ease critical paths in the production process. This has meant ordering, and in some cases constructing, some of the components of the structure, such as drives, encoders and the largest mechanical assemblies, before the Final Design Review has been performed.

The Large Mechanical Assemblies

One of the biggest challenges that the Italian consortium AES (Ansaldo Genova, EIE Venice, SOIMI Milan) encountered was to design a system, in spite of the large dimensions and masses involved, with a high first locked rotor eigenfrequency (8 Hz) which will consequently allow a high control loop bandwidth (about 3 Hz according to what Martin Ravensbergen, responsible for the telescope main axis control system, foresees with feasible design).

As a consequence, the disturbance rejection capability of the telescope will be such that the tracking of the telescope under wind buffeting, whose energy content is significant up to about 1 Hz and which is the most important disturbance effect overall, will allow us to reach the accuracy of 0.05″ RMS in autoguiding mode at least 60 % of the nights without the need to use M2 field stabilization, while the accuracy will become 0.03″ RMS in all conditions using M2 field stabilization.

After the Preliminary Design Review carried out in November 1992, the analysis of the dynamic performance of the main structure has been refined in more and more detail. During this process it was discovered that the preliminary design model did not properly take into account the real interaction between the structure, the centring azimuth hydrostatic bearing and the azimuth drive, and that the preliminary model introduced some extra stiffness which had led us to overestimate the first locked rotor eigenfrequency around the altitude axis. After removing the overconstraint, the first locked rotor around altitude resulted in about 6.5 Hz, very far indeed from the value specified by ESO.

Several solutions have been studied since then to increase this eigenfrequency which was dominated by the radial displacement of the centring azimuth hydrostatic bearings, in itself virtually infinitely stiff, causing the deformation of the base frame thus allowing rotation of the fork arm.

The solution was found by AES changing the load introduction pattern in the fork arm. This modification led to a first locked rotor eigenfrequency around the altitude axis of 8.11 Hz.

The lowest natural frequency of the telescope is about 7.2 Hz, but the mode is such that it is neither excited by the drive motion nor by the wind due to the protection provided by the enclosure, and thus will not reduce the disturbance rejection of the main structure.

This achievement of the specified first locked rotor eigenfrequency has closed the activities on the structural design and has started the activities of production of the final drawings for procurement and construction of the large mechanical assemblies. Moreover, this has also validated the design of the azimuth bearings whose tracks have already been built and are being machined in the Ansaldo factory in Genova (Fig. 1).

The Hydrostatic System with Active Centring

The completion of the structural design has brought us to the definition of the boundaries of the centring azimuth bearings.

These are the radial bearings which run around the inner azimuth track and centre the telescope azimuth axis.

The preliminary design of AES foresaw a passive arrangement which made use of the mechanical structure as a spring to allow the accommodation of differential displacement of the base frame of the fork with respect to the inner track due to temperature difference, or to run-out tolerance of the track itself.

A more detailed analysis of the behaviour of the system under the extreme functional temperature range has brought us to rethink the passive solution, due to the danger of possible jamming if the relative displacement caused the maximum allowable load in the pad pockets to be reached.

Now the solution for the centring pads consists of four pairs of pads each controlled by an electrovalve which will maintain the load on the pads constant at about 15 t. This will be done acting on the volume of the pad back-chambers by injecting or letting out oil in a continuous manner.

Even though this system was designed mainly as a safety device it will also be useful to centre the azimuth axis at a better level than the minimum run-out of the track.

The centring bearings were the last open issue concerning the hydrostatic system.

The prototype of the azimuth axial bearing has already been thoroughly tested by Riva Hydroart in Milan (Fig. 2) and has been proved to fulfil the requirements of the VLT main structure. The production of the azimuth axial bearings is already going on and already four pairs of pads for the azimuth axis of one telescope have been prepared for final machining (Fig. 3).

The Drive System

Also the final design of the drive system has been completed. Two segmented motors on the altitude axis of 36 kNm maximum continuous torque each and 2.6 m diameter and one segmented motor on the azimuth axis of 125 kNm maximum continuous torque

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Beginning of Construction

Left: *This impressive photograph of the Paranal mountain and future VLT site was published in the January issue of the National Geographic Magazine. It was taken by Roger Ressmeyer. The picture clearly shows the location of the four 8-metre telescopes. Also visible is the final stretch of the road designed to facilitate the transport of the 8-metre mirrors from the telescope to the aluminization plant in the Hotel Area, about 3 km from the summit. One can also see the two locations of the seeing monitor, details of which were given in previous issues of "The Messenger", and the meteorological tower which will be part of the astronomical weather station which will serve as an essential complement to the utilization of the VLT. During the current months a consortium comprising the Swedish company Skanska and the Chilean company Belfi will start the final excavation of the remaining part of the site which will house the interferometric complex and tunnel between the unit telescopes. Then they will proceed to pour concrete and initiate construction of the observatory.*

M. TARENGHI, ESO

Figure 1: *The azimuth outer track segments are laid onto the tooling machine for milling at Ansaldo factory in Genova.*

and 9.5 m diameter are directly coupled to the relevant axis, driving the telescope without introducing friction.

A first reduced scale prototype of the motors has been tested at PHASE in Genova and the ripple torque has been measured giving results which confirmed the FEM calculation performed and proving this solution to be well within the specified values. Some more tests will be carried out to better characterize the system.

The production of the permanent magnets is already going on, as well as the production of the control electronics which is being done by SOPREL in Milan.

The tachometer is directly coupled to the axes and is in fact a segment of the same motor.

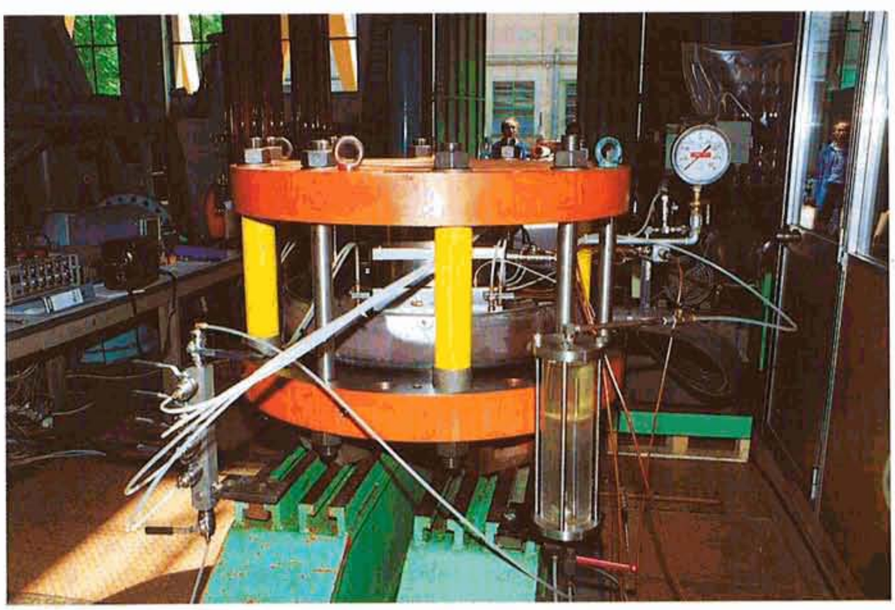

Figure 2: *The prototype of the azimuth axial pads on the test rig in the test lab of Riva Hydroart in Milan.*

The Encoders

If to design the mechanical structure for such a high dynamic performance was a big problem, no less of a problem was to find a suitable solution for the encoder of the VLT.

The high accuracy, stability and interacting speed required by ESO's specifications called for a directly coupled encoder with all the problems that such a requirement brings in a machine with axes of 2.5 and 9.5 m diameter.

The solution proposed by AES was based on the products of the American company Optodyne, which produces length measurement devices based on laser Doppler measurement.

This solution is well established for measurement of linear distances but this is the first time that this has been implemented to measure angles.

For this reason a fairly large qualification programme has been developed by Optodyne under AES's supervision to prove that the demanding requirements for the VLT encoder were satisfied.

Figure 3: *The first series of azimuth axial pads ready to undergo final machining at the factory of Riva Hydroart in Milan.*

Figure 4: *The telescope foundations in the test hall of Ansaldo in Milan.*

At the end of this programme the results have reasonably proved that the system as designed can fulfil the requirements, and especially has shown a fairly large flexibility in mounting tolerances, which is very much appreciated in the case of fitting on large diameters such as for the VLT.

Foundations in Milan

Since November last year in Ansaldo premises in Milan, AES has been preparing the test facilities for the main structure.

The foundations have been dug out and the concrete walls which simulate the concrete pier on which the telescope will be mounted on Paranal has been built (Fig. 4).

The next operation will be to place the interfaces with the azimuth tracks and to align them within 0.5 mm planarity. This will be a very interesting task which ESO will follow carefully because of the information which can be gained for the same operation to be performed on Paranal.

Next Steps

The redesign needed to meet the dynamic specification has caused a delay in the activities planned to deliver the first telescope on Paranal in April 1996.

AES has prepared a series of recovery actions which will allow the delivery of the first telescope in July 1996.

The first telescope will be ready for ESO testing in Milan starting from August 1995.

Before getting to the final act of declaring the telescope fully compliant with the requirements, we are sure we will encounter many problems which we will have to solve.

Nevertheless, the results of the final design assure us that all the provisions are there to provide the astronomical community with an instrument at the limit of the technology which is allowable today, and which has the potential to provide performance as required.

A New Approach for the In-Situ Cleaning of VLT Mirrors: The Peel-Off Technique

P. GIORDANO, ESO

1. Introduction

This paper describes the second approach[1] selected by the VLT Telescope Group for the *in-situ* cleaning of VLT mirrors.

The use of a strippable adhesive coating to remove dust and other organic contamination is a somewhat unconventional cleaning procedure but has proved to be effective in removing even small particles and providing a perfectly clean surface.

To apply the material onto the optical surface, it is preferable to use a soft brush or a non-contact technique. After a drying phase, the duration of which depends on the ambient conditions, the cured film is removed from the surface by attaching adhesive tape to the edge of the film. During the removal phase, known as the "peel-off process", all the contaminants, including sub-micron particles trapped by the material, are removed from the optical surface.

Various market products mainly dedicated to the cleaning of small optical components were tested and discussed by J. Bennett [1]. Their scaling-up to large optical mirrors was only possible at great cost and without any guarantee for the film removal on large areas.

For the reasons mentioned above, the VLT Telescope Group decided to carry out its own research programme.

2. Requirements

The selection of a suitable cleaning product was based on the following criteria.

Cleaning efficiency: This parameter could be expressed as the possibility to

[1] The first approach is the CO_2 snow-flake technique currently in use at La Silla. See next article.

restore reflectivity and micro-roughness of the mirror by approaching the values of a freshly coated Aluminium (Al) mirror by at least 95%.

Removal capability: For large optical surfaces, the dried film shall be removed in one piece, with no risk of breakage. The peel-off of a 2-m diameter mirror is the first challenge. The final goal would be to treat a mirror as large as the 8.2-m VLT M1 mirror.

Applicability: The fragility of the Al coating, as well as the mirror glass substrate, compels us to concentrate our attention on the application of the cleaning product by non-contact techniques.

Safety aspects: This last requirement concerns the purity of the product and also the absence of chemical solvents. Additional contamination by organic components of the optical surface shall not be tolerated. The application on large surfaces shall be made with a maximum of safety for the personnel and the environment.

3. Selected Product

The first run of investigations started with the German chemical company Bayer AG in Leverkusen and has proved useful. Mr. Zöllner rapidly understood the ESO cleaning requirements, and a good professional interaction was established. After three or four working runs the ideal product corresponding to ESO's criteria of cleaning efficiency, removability and safety, was established.

The second part of the investigation was carried out with the collaboration of two other companies. The IRSA company, a producer of high-tech varnishes, modified the selected Bayer product in such a way that it could be used with the mirror in vertical position, without any deterioration of the good cleaning properties of the product. The firm Jahnke GmbH, a representative of the company Wagner, advised us in the selection of the spray-gun unit, the "Fine Coat", which is particularly suitable for application of thixotropic material.

4. Experiments

Intensive tests were conducted in the optical laboratory in Garching using the various IRSA formulations and achieving a uniform spraying on optical surfaces. Proof of the suitability of the product was obtained at La Silla Observatory during the technical time allocated for the installation of the CO_2 cleaning device on the NTT (28 September – 10 October 1993).

4.1 Cleaning efficiency evaluation

Dust contamination of the optical surfaces is currently evaluated at ESO-Garching by using the μScan scatterometer [2]. It is a portable instrument, purchased from T.M.A. Technology (USA), designed to measure the quantity of light scattered by surface irregularities (Bi-directional Reflectance Distribution Function or B.R.D.F.) regardless of whether they are surface micro-defects or dust contamination. Another parameter provided by this instrument is the surface reflectivity at the wavelength of 670 nm. From the scattered light measurements an equivalent micro-roughness value of the optical surface (RMS) has been computed.

The regular use of the μScan, both in the laboratory and *in-situ* on telescopes, confirms the high sensitivity of this equipment and its suitability for the evaluation of dust contamination on optical surfaces and in the selection of cleaning products and techniques.

4.2 Removal test: (see photo)

Several removal tests have been performed on the "1.6-m test plate" stored in the metalization plant of the 1.52-m telescope building. The experiment has been carried out in better conditions than in Garching, mainly due to the extremely low air humidity, typically 15%. Several layers of product were applied to the vertical surface, without any running of the material. An optimally dried film with a thickness of about 100 micrometres allowed us to savely remove the film, that is without breakage. Difficulties still remain with regard to starting the removal process, but when the first centimetres at the edge are free, the film removal can be performed with two hands.

4.3 Cleaning the "Chilimap"

The 40-cm telescope (Chilimap) stored in the previous metalization plant had been out of service for at least 15 years and its main mirror was never recoated. The *in-situ* cleaning was carried out successfully. No measurements of reflectivity or micro-roughness were performed before cleaning, but values

TABLE 1.

	BRDF[1] [0,0][2]	BRDF [50,180]	Reflectivity %	RMS Å
1st cleaning	9.224E-04	1.465E-04	86.8	27
2nd cleaning	5.908E-04	1.008E-04	87.0	21.4
NTT M3 mirror (freshly coated)	8.909E-04	1.274E-04	89.6	29.1

[1] Bi-directional Reflectance Distribution Function measured as scattered power normalized by the incident power and the cosine of the polar angle.
[2] [0,0] and [50,180] are the locations of the two scatter detectors.

obtained after two consecutive cleaning processes are excellent and may be compared with the values of a freshly coated mirror (see Table 1).

4.4 Comparative study

A comparative cleaning study has been conducted taking as reference the product Opti-Clean, the stripping material giving the best cleaning results [1] and which has been regularly used at ESO for the cleaning of small Al coated mirrors. The advantages of the "XL Clean 5" coating are shown in Table 2.

TABLE 2.

	Opti-Clean	XLClean 5
Organic solvent	90 %	none
Solid resin	10 %	approx.37 %
Cost	high	low

A flat mirror (diameter = 158 mm) with a protected reflective layer was exposed for 5 years to the dust contamination of our laboratory. Half of the mirror has been cleaned using the Opti-Clean and the other half with the product selected by ESO, known as XL Clean 5. The results are shown in Table 3.

TABLE 3.

	BRDF (0,0)	BRDF (50,180)	Reflectivity %	RMS Å
Dusty mirror (full surface)	1.555E-02	1.429E-02	78.6	93.5
XL Clean 5 process (1/2 part)	3.327E-04	5.840E-05	87.3	15.6
Opti-Clean process (1/2 part)	5.641E-04	8.335E-05	87.6	29.1
XL Clean 5 on complete surface	2.720E-04	3.920E-05	87.3	15.4

5. Technical Data

Name: XL Clean 5

Based on a polyurethane emulsion produced by Bayer AG. Easy application with a spray-gun. Multilayer application recommended to obtain a final dried film of 100 micrometres. Drying time about 2.5 hr largely depending on the relative humidity of the air. No special safety regulations to be applied during the application of the product. Possibility of removing any product remains during washing of the mirror surface before the coating operation. Consumption: 500 g/m^2

6. Conclusion

The product selected by ESO fulfils our requirements for the *in-situ* cleaning of large mirrors and has been successfully tested for mirrors up to diameter 1.6 m.

A normal precaution before using such a new product in the cleaning of astronomical mirrors is to perform a first test on a small area of the mirror or better still on a sample plate. This precautionary measure is recommended to evaluate the adhesion quality of the Aluminium coating over the glass surface.

Another advantage of this peel-off product is that it provides protection during packing and trans-oceanic transportation of expensive and delicate optical pieces. A long-term ageing test of the XL Clean 5 product has been initiated at ESO.

References

[1] Jean M. Bennett, Lars Mattson, Michael P. Keane, and Leif Karlsson. "Test of strip coating materials for protecting optics." *Applied Optics*, Vol. **28**, No. 5, 1 March 1989, page 1018.

[2] T.M.A. Technologies, Inc. P.O. Box 3118 BOZEMAN, MT 59715.

In-Situ Cleaning of the NTT Main Mirror by CO_2 Snow-Flake Sweeping

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1. Introduction

Since the beginning of 1992 most telescope mirrors on La Silla have been cleaned regularly using the CO_2 snow-flake technique. Although this manual operation could be considered an easy one for some telescopes on La Silla, it has sometimes required mountaineering skills on the part of the operator. In fact, this preventive cleaning operation has become a very delicate and risky undertaking.

The CO_2 cleaning method, preselected for the optical maintenance of VLT mirrors, should be an improvement on the conventional manual methods and should be tried out on existing telescopes before its implementation on the VLT.

A telescope such as the NTT working in a well-ventilated dome is more exposed to dust contamination than an older telescope. A prototype CO_2 snow-flake cleaning project was therefore proposed at the beginning of 1991 for the NTT. This selection was also guided by the idea to finalize the original concept of the NTT. It should be remembered that a cleaning system, based on a wet process, was foreseen earlier and that part of it was already included in the M1 cell design, but never completed.

Experience gained during the installation phase of the NTT on La Silla was of paramount importance for the development of the ESO concept of CO_2 cleaning.

2. Realization

A contract was awarded at the end of September 1992 to the company ICMP for the final design, manufacturing, assembly, testing and transportation to Chile of the cleaning device.

ICMP is a small engineering/mechanical company located in France close to Grenoble. The engineering staff of this company were involved, directly or indirectly, in the construction of various mechanical sub-systems early on in the

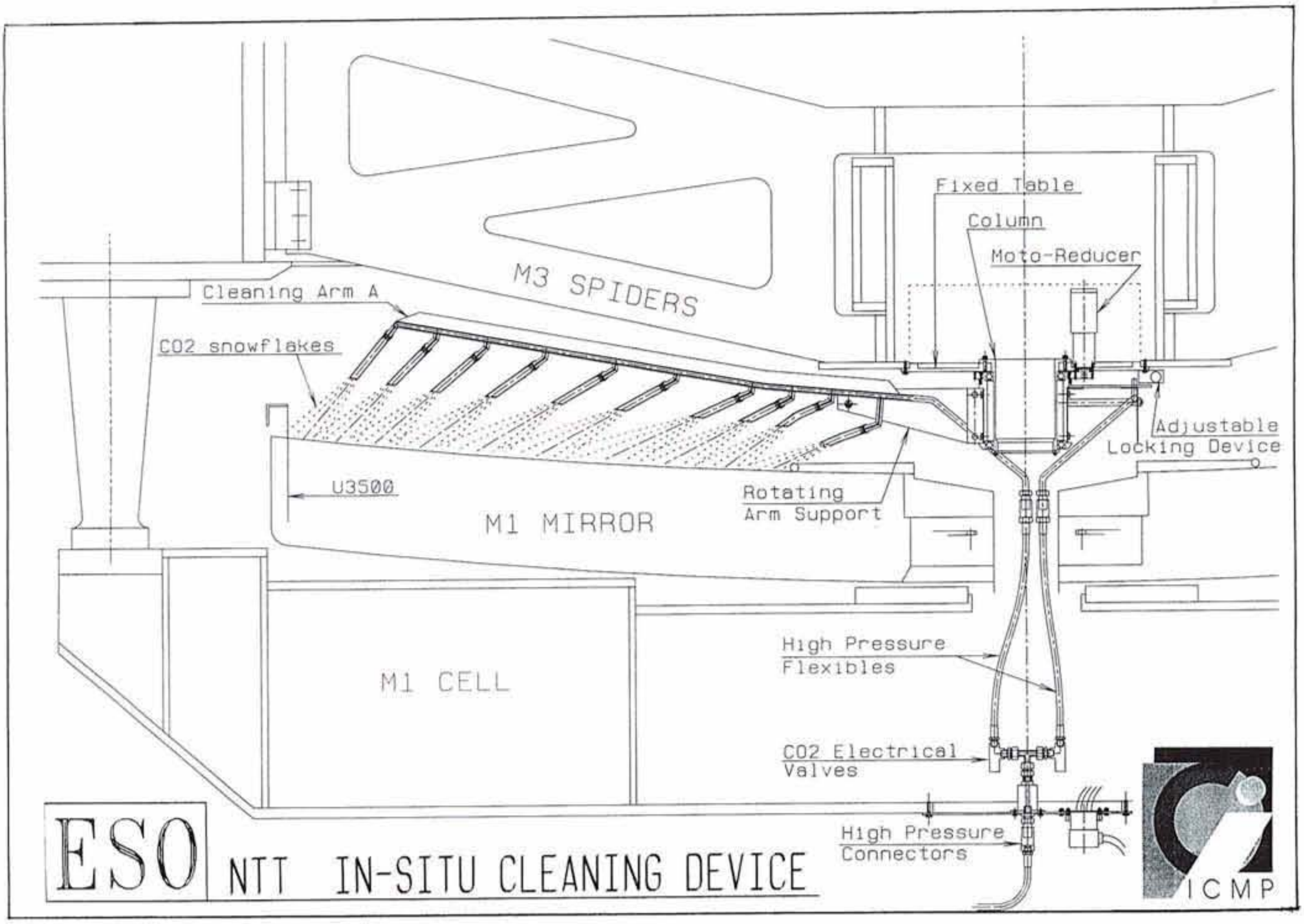

Figure 1.

3.6-m telescope project and more recently in the NTT. The NTT M1 mirror handling tool and altitude axis lock-pin were constructed by them.

After tests on an internal prototype, the company solved a great many problems connected with the critical use of cryogenic products. The main goal was to obtain a final pre-adjusted product, easy and safe to operate. Figure 1 illustrates the final concept.

3. Description of the CO_2 Cleaning Device

Two arms with a series of 10 injectors are connected to a turntable fixed under the M3 unit of the telescope. In the rest position they are totally in the shadow of the M3 spiders.

For the cleaning operation, during day time, the telescope is inclined to at least 70 degrees. Connection is made to two electrical and one CO_2 pipe connectors. The electrical control cabinet and the CO_2 cylinders are permanently installed in the dome. The operator, facing the M1 mirror and using a portable handset, can start and control the cleaning operation. The cleaning device is removed from its parking position. The arm rotation and the ejection of liquid CO_2 are accomplished simultaneously for the left side of the mirror which receives a high quantity of CO_2 snowflakes. (See Figure 2.)

On reaching the lowest point of the M1 the liquid CO_2 distribution is stopped and transferred to the right-hand arm which is now at the top position of the M1.

The rotation motion is maintained until the lower point of the M1 is cleaned again. The pipes are now purged with CO_2 gas and the CO_2 cleaning device is

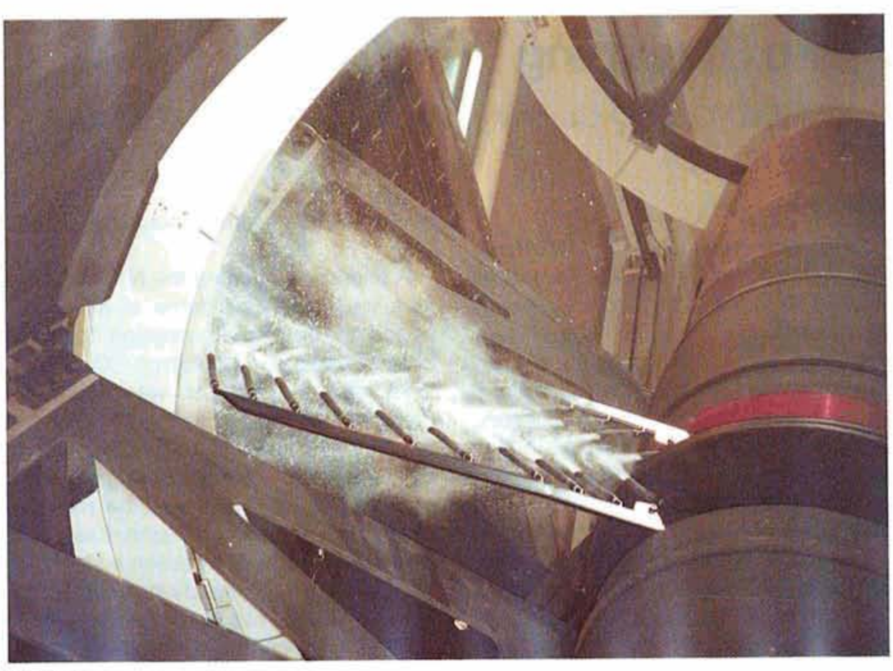

Figure 2.

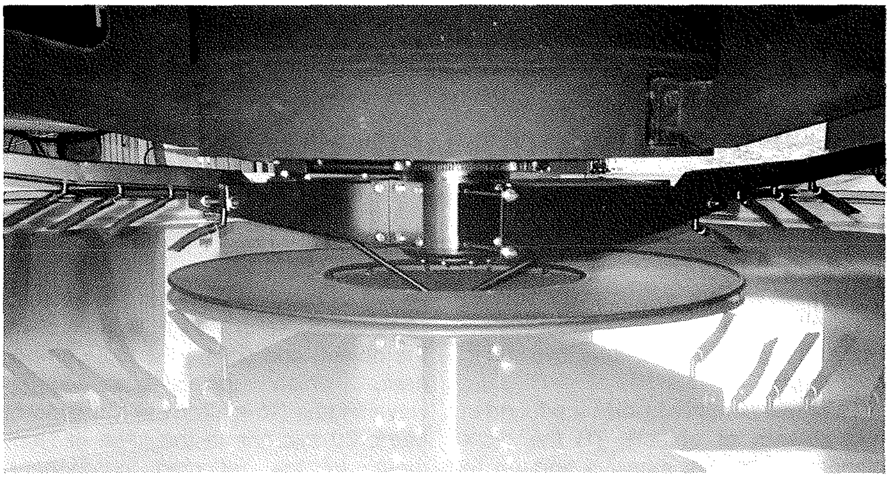

Figure 3: *View of the turn-table*

one year before, but cleaned regularly manually with the same CO_2 snow-flake technique except during the last two months previous to this installation.

After three successive cleaning operations, several circular zones appeared on the mirror surface corresponding to the direct impact of the CO_2 jets.

Measurements at an ambient temperature of 10 degrees with the Uscan scatterometer are listed in Table 1.

The limitations of this technique are well known and are illustrated by the present test. Extremely fine particles settling for a long time on the optical surface and suffering humidity variations and/or electrostatic charge need extremely high forces for their removal. However, it is important to remember that this cleaning technique was proposed and investigated with the objective of regularly removing dust contamination deposited over a *clean* mirror.

We will know more about the efficiency of this technique after the re-coating of M1 (next year) and the regular weekly cleaning of its surface, with monitoring of reflectivity and light scattering.

then parked under the M3 spiders. The cleaning process duration (the only adjustable parameter) was optimized to twice 45 seconds!

4. First Installation and Tests

A period of five days was reserved at the NTT at the end of September 1993, for the installation, testing and staff training for the CO_2 snow-flake cleaning device. It has been installed in the free space between the main mirror and the M3 Unit.

The supply pipes (liquid and gas CO_2, electricity) pass through the central hole of the main mirror and its cell. A plate at the back of the M1 cell will receive the various connectors. Flexible pipes will ensure interfacing between this plate and the CO_2 cylinders resting on the telescope floor.

After adjustment of the two arms in the shadow of the M3 spiders, several tests were performed to check:

- the rotation of the arms
- the parking position (stability, reproducibility, efficiency)
- the transfer of CO_2 liquid and gas
- the safety functions (electro-valves, emergency button, etc.) and the cleaning of the pipes using clean CO_2 products.

Three cleaning processes were performed to evaluate the efficiency of the system and to train staff from the Optical Group on La Silla.

5. Results and Comments

Measurements of mirror reflectivity at 670 nm as well as part of the light scattered by dust contamination were carried out, using the portable Uscan scatterometer.

The cleaning evaluation was performed on quite a dusty mirror, coated

6. Conclusion

The CO_2 cleaning prototype installed on the NTT seems user-friendly and easy to operate, important parameters to justify weekly utilization. With this cleaning periodicity, which has already been adopted, only a limited additional contamination is expected.

TABLE 1.

	BRDF[1] (0,0)	BRDF[1] (50,180)	REFLECT. %	ABS[2] R %	RMS Angst.
Dusty mirror	1.325E-02	6.474E-03	79.1	82.7	86.9
After 1st cleaning	1.100E-02	4.004E-03	80.6	84.2	80.3
After 2nd cleaning	1.051E-02	3.581E-03	80.8	84.4	79.0

[1] Bidirectional Reflectance Distribution Function.
[2] Absolute reflectivity measurements computed with reference to a dielectric mirror.

Observation of Solar-System Objects with the VLT

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As a continuation of various active ongoing programmes of ground-based planetary observations, many promising research developments can be anticipated from planetary observations with the VLT, especially in the near-infrared range. The use of adaptive optics will be essential to reach the full capabilities of the VLT, both for imaging and for spectroscopy.

Introduction

In spite of a successful space programme developed over the two last decades, there are still important questions wich remain unsolved concerning our understanding of Solar-System bodies. In fact, on many occasions, the new results coming from space data have raised new questions, dealing, in particular, with formation and evolution processes. As an example, the study of the chemical composition of planetary and cometary atmospheres has led, in several cases, to unexpected results which have been used as tests against formation and evolution models.

Ground-based observations have provided a very important contribution as a complement to space missions. In particular, our knowledge of the chemical composition of the atmospheres of the giant planets has been mostly inferred from ground-based infrared spectroscopy. Observations of stellar occultations, obtained simultaneously from several ground-based or airborne telescopes, have provided the first detection of Uranus and Neptune rings; they also have allowed the exploration of the upper atmospheres of Jupiter, Uranus, Neptune and Titan. Taking advantage of the newest technological developments, the planetary ground-based exploration programme is still very active, as illustrated by the international campaign presently organized in all observatories for monitoring Jupiter at the time of the collision of comet Shoemaker-Levy 9 with this planet, around July 20, 1994.

The Astrophysical Problems

One of the major astrophysical interests of observing Solar-System bodies is that they can provide clues about the origin of the Solar System. By studying objects in various evolutionary stages, information can be derived about formation and evolution processes involved in their history.

The most primitive bodies are found in two classes of objects: (1) the giant planets, which are massive enough to have accreted around their core the surrounding gas of the primordial nebula; (2) the comets, which are small and cold enough to have escaped any evolutionary process since their formation. In these objects, the chemical composition and the elemental and isotopic abundance ratios (such as He/H, D/H and C/H) are powerful indicators of their origin scenario and their history. Another important diagnostic is given by the study of the surface of the solid bodies (asteroids, cometary cores) and their physical and dynamical properties.

The atmospheres of the terrestrial planets have evolved significantly since their origin; indeed, a major and fascinating problem in planetology is the comparative study of the evolution of the atmospheres in the case of Venus, the Earth and Mars. Here again, the chemical and isotopic composition (in particular the D/H ratio) can provide important tools which constrain the evolutionary models of these planets.

In addition, monitoring the spatio-temporal behaviour of planetary atmospheres is a key element to address specific problems, presently poorly understood: climatology in the case of Mars and Venus, general circulation and auroral phenomena in the case of the giant planets, ices sublimation and outgassing of a comet as it approaches the Sun... In these specific cases, the planets and comets can be considered as priviledged laboratories, in which a large variety of physical and chemical processes can be investigated.

The Observations to be Performed

What are the observations which will allow us to address these questions? For determining the chemical composition of planetary and cometary atmospheres, high-resolution spectroscopy is best suited. The infrared and millimetre ranges are of special interest for the study of neutral molecules. The spectrum of a Solar-System object is composed of two components: (1) the solar component, reflected or scattered by the object, and (2) the thermal component, which peaks at longer wavelengths (15 microns in the case of Mars, 70 microns in the case of Neptune). In the reflected component, atmospheric constituents show absorption features giving information upon the column density of the absorber. In the thermal part of the spectrum, the outgoing flux refers to the atmospheric level where the optical depth approximates unity. The line can thus appear in emission or in absorption, depending upon the shape of the thermal profile and the sign of the temperature gradient. The observed lines can be used to obtain information upon the vertical distribution of the molecule. In addition to these components, Solar-System objects, and comets in particular, can show fluorescence emission lines, in the UV, the visible or the IR range.

In addition to spectroscopy, imaging techniques provide useful information on the surface of objects like the Moon, Mars and the giant planets Jupiter and Saturn. Multiband CCD and infrared imaging allows to map the mineralogy of surfaces, or to monitor the cloud morphology of the giant planets. This technique is being improved with the ongoing development of imaging spectroscopy, which allows, at least on the bright planets, a coupling of both spatial and spectral capabilities.

Another powerful technique is the photometric monitoring of a stellar occultation by a planet. As the planet passes in front of the star, the stellar flux is refracted by the planet's atmosphere. By studying the stellar lightcurve at the time of immersion and emersion, it is possible to derive the refractive index of the atmosphere. In addition, this method allows the detection of rings around the planets; it provided the first evidence for rings around Uranus and Neptune.

A Few Recent Results from Ground-Based Observations

High-resolution spectroscopy in the near-infrared (1–5 microns) has led to major discoveries over the past few years. A few examples are given below.

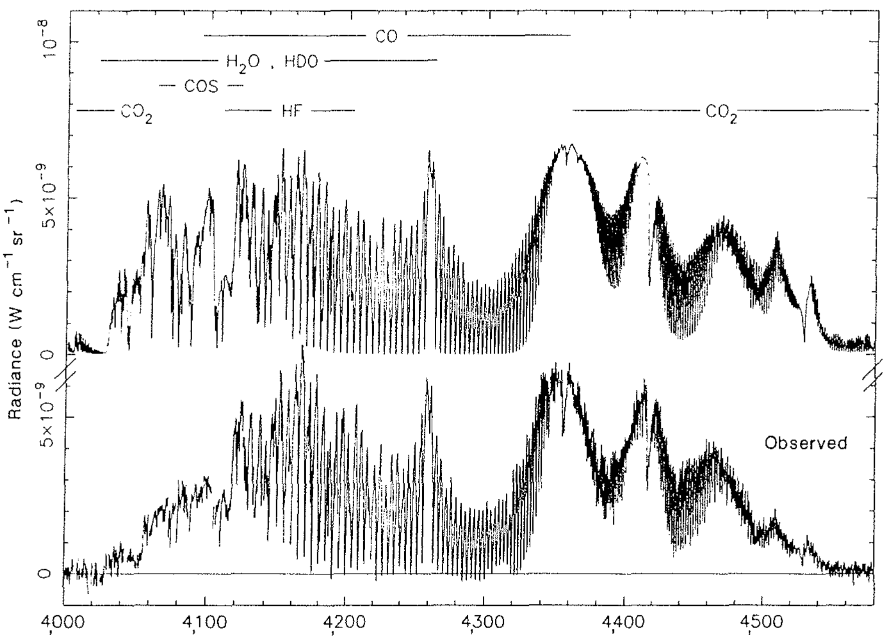

Figure 1: *The 2.3-micron spectral window in the spectrum of the dark side of Venus (FTS, CFHT). The spectral resolution is 0.23 cm^{-1}. The figure is taken from Bézard et al. (1990).*

The lower atmosphere of Venus, below 50 km, is hidden by a thick and opaque cloud which prevents it to be observed at almost all wavelengths. However, there are a few discrete near-infrared spectral windows, between the strong absorption bands of the dominant atmospheric constituent CO_2, where the thermal radiation is emitted from the lowest cloud layers. High-resolution spectroscopy of these regions (Bézard et al., 1990; Fig. 1), performed with the FT spectrometer of the 3.6-m CFH telescope at Mauna Kea (Hawaii), has led to the abundance determination of various minor constituents (H_2O, CO, COS, SO_2, HCl, HF, HDO), either from the 2.3-micron window or from the 1.8-micron window. The D/H ratio has been found equal to 120 times the terrestrial value (de Bergh et al., 1991). According to evolutionary models of the planet, this strong deuterium enrichment would imply a high abundance of water in Venus' past history.

In the case of the giant planets, there is also a "spectral window", where there is no absorption by the dominant absorber CH_4. This is the 4–5-micron region, where thermal radiation comes from deep tropospheric levels (a few bars in the case of Jupiter). This range is thus best suited for searching minor atmospheric species. CH_3D, GeH_4, CO and more recently AsH_3 have been detected in both Jupiter and Saturn. Another important result has been the unexpected detection of the H_3^+ ion in an auroral spot of Jupiter at 2.1 microns and later at 4 microns (Drossart et al., 1989, 1992). These emission lines could originate from thermal emission in the hot atmosphere.

Cometary research has also benefited from near-infrared spectroscopy. This is the spectral range where parent molecules, directly outgassed from the nucleus, exhibit their strongest fluorescence emission signatures. Comet Halley provided a unique opportunity for this research. High-resolution observations with the 0.9-m telescope of the Kuiper Airborne Observatory, in the 3-micron region, provided the first observational evidence for the presence of water vapour in a comet (Mumma et al., 1986; Larson et al., 1988; Fig. 2). The same experiment was repeated later on other bright comets. The observations provided the abundance of H_2O, the temperature, the velocity field, and an estimate of the ortho-to-para ratio of water, which can provide a constraint upon the temperature at the time of the comet formation.

Another area of successful spectroscopic research is the study of fainter and fainter Solar-System objects, made possible with the development of more and more sensitive spectrometers. A remarkable example is provided with the recent detection of N_2, CH_4, CO and CO_2 ices on the surface of Neptune's satellite Triton (Cruikshank et al., 1993; Fig. 3), with the CGS4 cryogenic spectrometer at the UKIRT 3.8-m telescope (Mauna Kea, Hawaii), using moderate spectral resolution (R = 300).

Because infrared observations re-

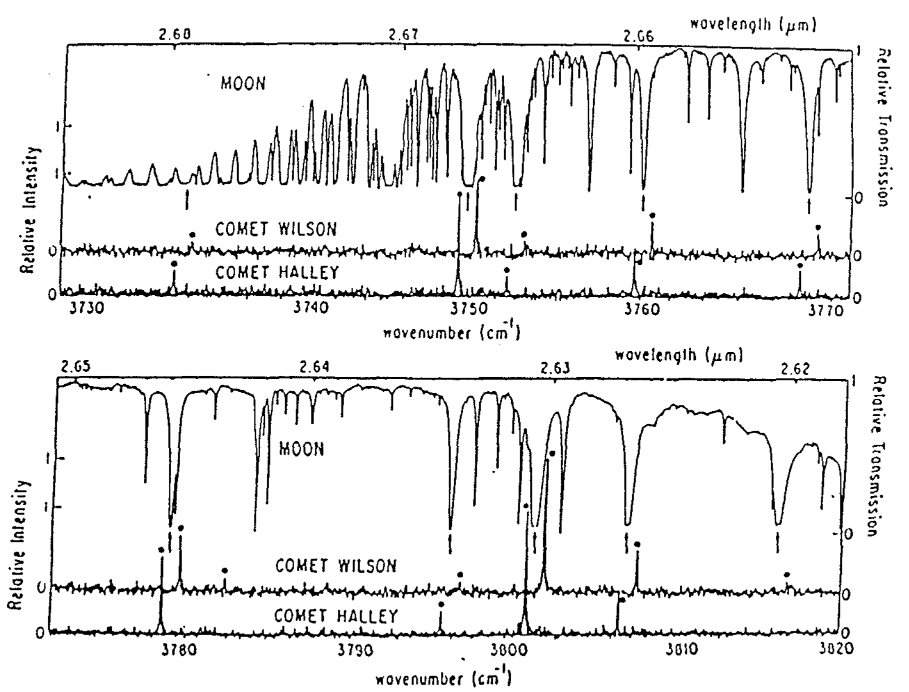

Figure 2: *The high-resolution spectrum of the 2.7-micron H_2O band recorded with the FTS of the Kuiper Airborne Observatory in comets Halley and Wilson. The resolving power is 100,000. Upper curve: Moon (atmospheric transmission); lower curves: Wilson and Halley. The absolute Doppler shift is in the range 0.4–0.5 cm^{-1}, and is sufficient to separate the terrestrial water lines (shown in absorption in the lunar spectrum) from the cometary emissions. Both cometary spectra are uncorrected from atmospheric transmission and instrumental response, but the lunar spectrum is used to calibrate the relative intensities. The figure is taken from Larson et al. (1988).*

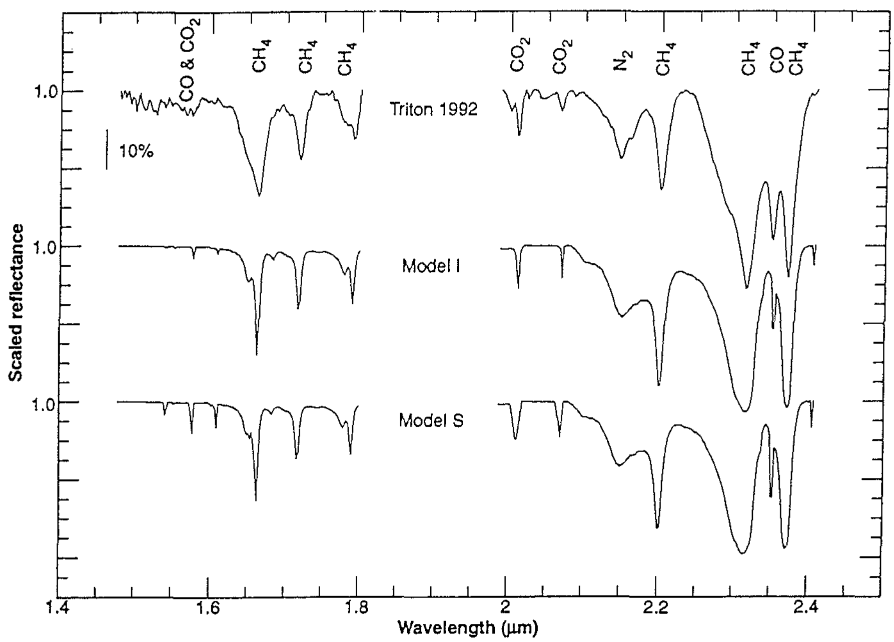

Figure 3: *The infrared spectrum of Triton in the near-infrared range. Upper curve: observations; lower curves: scattering models including ices of N_2, CO, CO_2 and CH_4, with two abundances of CO_2 (0.10 % in Model I, 10 % in Model S). The figure is taken from Cruikshank et al. (1993).*

quest a very dry terrestrial atmosphere, most of the results mentioned above have been obtained in high-altitude sites or even from aircraft. However, in the visible and near IR (below 2.5 microns), the amount of terrestrial water vapour is less critical. Two very significant results have been obtained in planetary physics using the 3.6-m ESO telescope on La Silla: the first one is the detection of rings around Uranus (Sicardy et al., 1982) and Neptune (Hubbard et al., 1986), using the stellar occultation technique; the second is the first imaging of Solar-System objects (Titan, Pallas and Ceres) at the diffraction limit in the near-infrared, using the adaptive optics instrument (COME-ON) at the 3.6-m ESO telescope (Saint-Pé et al., 1993; Fig. 4). The latter results open a new field of Solar-System imaging observations, which is likely to develop in the forthcoming years.

Solar-System Observations with the VLT

With respect to a 4-m-class telescope, the use of the VLT is going to provide a double advantage: a factor 2 gain in spatial resolution, and a factor 4 in collecting flux (for unresolved sources, or for a constant aperture in the case of extended sources); the latter advantage implies, for photon-limited observations, a factor 4 in observing time.

The diffraction limit of an 8-m telescope is about 0.06 arcsec at 2 microns or 0.3 arcsec at 10 microns. Table 1 summarizes the maximum sizes of the brightest Solar-System objects, with the number of pixels of each object over the central meridian, at 2 microns and 10 microns respectively.

Assuming a seeing of 0.3 arcsec in the best cases, one can see that the factor 2 advantage in spatial resolution is achieved above a wavelength of 10 microns. At lower wavelengths, an adaptive optics system is needed. Based upon the present experience of the COME-ON+ instrument now operating at La Silla, we will assume, in what follows, that the VLT 8-m telescopes will be equipped with an adaptive optics system which reaches the diffraction limit for wavelengths higher than 1 micron. This high spatial resolution capability will be useful for direct imaging, but also for high-resolution spectroscopy (Encrenaz et al. 1992), as it will be possible to concentrate the whole flux of a weak object on the narrow (less than 0.5″) entry slit of a cryo-echelle grating spectrometer (R > 50,000).

Table 1 shows that a large number of Solar-System bodies will be spatially resolved at two microns. Two types of observations will benefit from the VLT: (1) high-resolution imaging spectroscopy of extended objects; (2) photometry and spectro-photometry of weak objects.

1. High-resolution imaging spectroscopy of extended objects

The expected performances are a spatial resolution of 0.06 arcsec and a spectral resolving power of 100,000 at 2 microns. The first targets to be studied are the bright extended planets: Venus, Mars, Jupiter and Saturn. A few specific examples are given below.

Imaging spectroscopy in the near-infrared has already been achieved, at moderate spatial resolution, to investigate the lower atmosphere of Venus on the night side of the planet. This has been achieved by coupling the FT spectrometer of CFHT with a bidimensional camera, providing the full spectral resolving power (40,000) and a spatial resolution of 0.5 arcsec (about 100 km on the surface of the Venus disk). In the future, the use of adaptive optics on a 4-m telescope will improve the spatial resolution by a factor about 5, which will correspond to the spatial resolution achieved by the Galileo probe at the time of its Venus flyby (Carlson et al., 1991). The use of the VLT will improve again this limit by a factor 2, allowing to investigate in more depth both the atmospheric composition and the complex cloud structure which was revealed by the Galileo data.

TABLE 1.

Solar-System object	Size (arcsec)	Number of pixels 2 microns	10 microns
Venus	60.0	1000	200
Mars	18.0	300	60
Jupiter	47.0	780	157
Saturn	19.0	317	63
Uranus	4.0	67	13
Neptune	2.3	38	7
Io	1.2	20	4
Europe	1.0	16	3
Ganymede	1.7	28	5
Callisto	1.6	26	5
Titan	0.8	13	2
Ceres	0.7	11	2
Pallas	0.4	6	1
Vesta	0.5	8	1

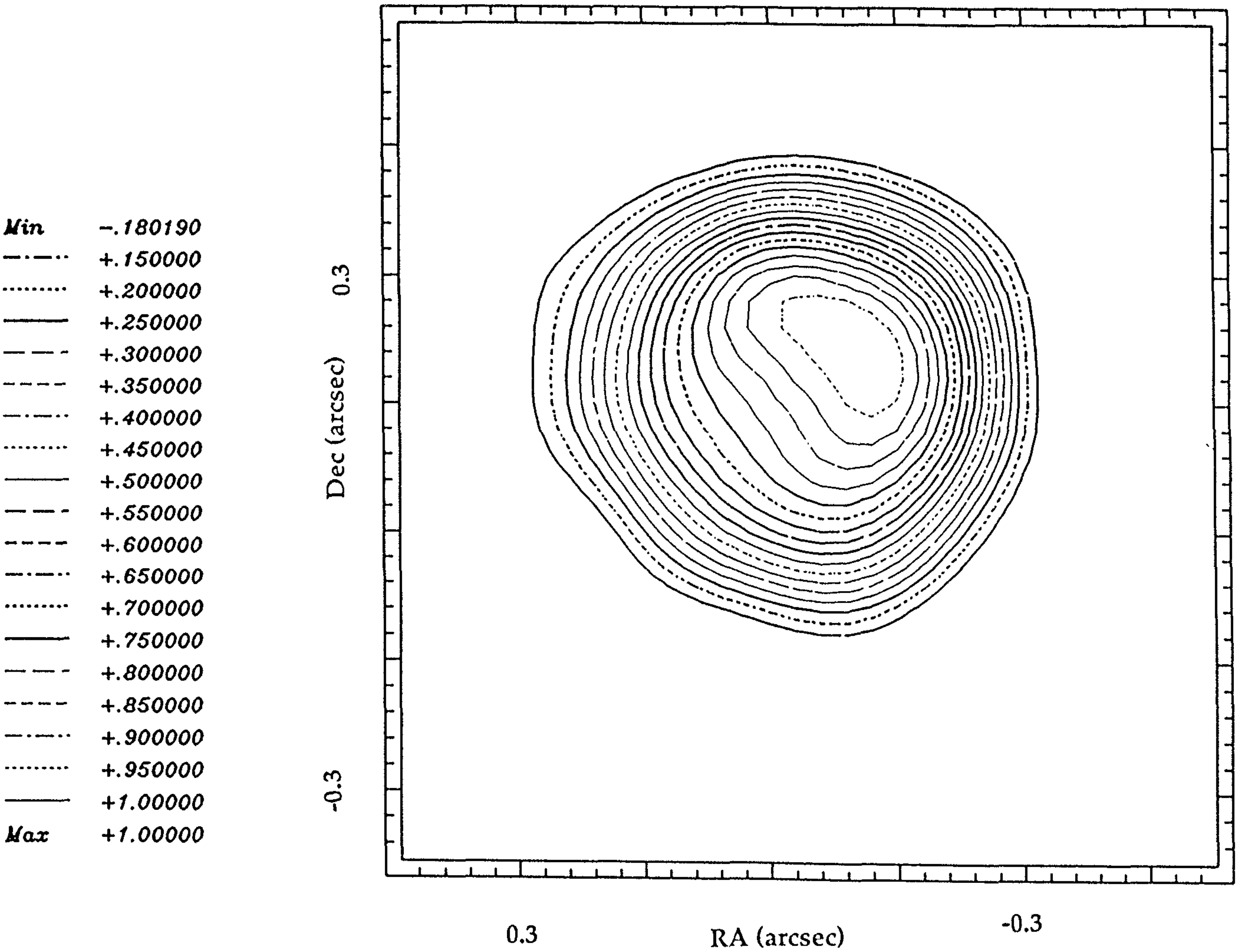

Figure 4: *Isophotes of Ceres in L'band. The image was recorded with the adaptive optics system COME-ON at the ESO 3.6-m telescope at La Silla, in May 1991. The spatial resolution is 0.25 arcsec, corresponding to the diffraction limit at 3.5 microns: The maximum level is normalized to 1 and two levels are separated by 5% in flux. The figure is taken from Saint-Pé et al. (1993).*

The study of the Martian atmosphere is also going to benefit from the use of high-resolution imaging spectroscopy. The distribution of minor atmospheric species, and especially CO, over the disk of Mars has been the subject of a large debate and is not yet fully understood. Combining high spatial and spectral resolution will allow to resolve the individual lines of the CO (2-0) band at 2.3 microns, and to study their spatio-temporal variation. At opposition, a spatial resolution of 25 km (0.06 arcsec) will be reached with the VLT, comparable to the resolution achieved with space orbiters like the PHOBOS spacecraft (Rosenqvist et al., 1992).

A third example is provided by the observation of H_3^+ in the auroral regions of Jupiter. Using an 8-m telescope with a diffraction limit of 0.06 arcsec actually achieved, it will be possible to reach both a spectroscopic resolving power of 100,000 and a spatial resolution of 200 km on the Jovian disk. The detectability of the Doppler-broadened H_3^+ lines should be increased by a factor larger than 10 with respect to the present data, and the improved spatial resolution will allow us to better define the contours of the existing aurorae and to identify hot spots. The same search could be attempted on other giant planets also, with the limitation of the available flux.

In the near-infrared range, the VLT will also allow us to map smaller objects, presently too small to be resolved both spatially and spectrally. The first exciting target is Io, which is known to have a stable, but apparently patchy, SO_2 atmosphere (Lellouch et al., 1992). Here again, observing the Doppler-broadened SO_2 line, at 4 microns requires maximum spectral resolution. Io will be fully resolved, with 10 pixels along the central meridian and a K-magnitude of about 10 per pixel, allowing a complete mapping of the atmosphere in correlation with the volcanic activity. Another promising target is Titan. First diffraction-limited images of Titan have been obtained in the near-infrared range, with the ESO 3.6-m telescope, equipped with adaptive optics. Titan's K-magnitude within a 0.06 arcsec pixel will be about 12, easily detectable with the VLT. Infrared spectroscopy will be needed to isolate the near-infrared windows, free from methane absorption, in order to probe the surface of Titan. The gain in sensitivity and spatial resolution provided by the VLT will be of extreme interest in preparation to the Cassini-Huygens mission, designed to explore Titan's atmosphere and surface in 2004–2008.

Another promising field of research is the observation of comets with the VLT. As mentioned above, the near-infrared range is very well suited for studying the Doppler-broadened fluorescence emissions of the parent molecules. Determining the spatial distribution of parent molecules in comets will be essential for

TABLE 2.

PLANET Satellite	Angular size	K-magni-tude
JUPITER		
Amalthea	0.08	12.8
SATURN		
Mimas	0.06	11.5
Enceladus	0.08	10.3
Tethys	0.16	8.8
Dione	0.16	9.0
Rhea	0.24	8.35
Iapetus	0.23	9.7
URANUS		
Ariel	0.09	13.0
Titania	0.12	12.6
Oberon	0.12	12.8
NEPTUNE		
Triton	0.19	12.3
PLUTO	0.14	12.5

understanding the thermodynamics of the coma. The use of the VLT will improve the sensitivity limit and/or increase the spatial and spectral resolution of the observations. For a comet located at 0.3 AU from the Earth, a spatial resolution of 0.06 arcsec corresponds to a diameter of 15 km, comparable to the size of a cometary nucleus; even for a more distant comet, it will be possible to probe the inner coma in detail. In addition, if the resolving power reaches 300,000, the Doppler lines can be resolved, providing a determination of the velocity field.

Finally, a special mention should be made about imaging spectroscopy of planets and comets in the thermal infrared range, in the 10-micron and 20-micron atmospheric spectral windows (Drossart, 1993). In particular, the giant planets and Titan show, in the 7–14-micron range, emission lines due to hydrocarbons which allow to probe the thermal structure of their upper atmospheres, to study the density distributions of these hydrocarbons and to monitor their spatio-temporal variations. Another exciting study could be the search for oscillations on Jupiter and Saturn, which should benefit from an improved spatial resolution for discriminating the various oscillation modes.

2. Photometry and spectrophotometry of weak objects

The use of the VLT will offer a factor 4 improvement in terms of collected signal, which translates, for photon-limited observations, into a factor 4 gain in observation time. A new class of faint objects, the bare satellites of the outer Solar System, can be observed with near-infrared spectrophotometry, for a determination of their mineralogic properties. Table 2 lists the angular size and the K-magnitude of some of them, too small to be imaged, but bright enough for spectrophotometric observations.

We can use as a comparator the recent observation of Triton, on a 3.8-m telescope, with a resolving power of about 300 and 4 nights of integration (Cruikshank et al., 1993). The same observation could be made in one single night with the VLT. Uranus' satellites could be observed at wavelengths up to 2.5 microns, with the same spectral resolution, in a few nights of integration time. It will also be possible to resolve a few pixels on the disk of Triton, as well as on the surfaces of Saturn's largest bare satellites.

Finally, a last programme to be mentioned is the photometric study of bare cometary nuclei. Comet Halley was monitored at the 3.6-m ESO telescope up to very large heliocentric distances, where some signs of activity were still detectable. A systematic search for activity on many distant comets will provide interesting constraints upon the nature of the volatiles outgassed at large distances from the Sun.

Observations of Solar-System Bodies with the VLTI

We have seen that the near-infrared range is well suited for the study of faint and cold Solar-System objects. The use of the VLTI will allow systematic studies on point-like objects such as asteroids and bare cometary nuclei. At a distance of 3 AU from the Earth, a diameter of 7 km (typical of a cometary nucleus) corresponds to an angular diameter of 10 milliarcsec, and could be resolved with the VLTI. Measuring the diameters, the shapes, the rotation period, the mineralogy and the thermal properties of a large number of samples will provide a statistical information which will be very important for constraining the dynamical models of these objects, and could open a new field of research. The use of VLTI might also allow to accurately localize hot spots on larger objects, like volcanoes on Io or auroral spots on the giant planets. At Jupiter's opposition, a 10-km volcanoe on Io would have an angular size of 10 milliarcsec and could thus be resolved, and a temporal monitoring of volcanic activity could be possible.

Conclusion

Many promising research programmes are expected to be performed on Solar-System objects with the VLT, using either the 8-m telescopes or the VLTI mode. An essential factor will be the availability of an adaptive optics system at the 8-m telescope foci, in order to take full advantage of the large size of the mirrors, both for imaging and spectroscopic observing programmes.

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High-Resolution NIR Imaging of Galactic Nuclei with SHARP

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High-resolution imaging from the ground is substantially easier in the infrared than at visible wavelengths. The seeing-limited angular resolution decreases with wavelength λ as $\lambda^{-1/5}$ or faster, the coherence time of the atmosphere increases with $\lambda^{6/5}$ or more, and the isoplanatic angle θ, over which the phase distribution is constant, increases with $\lambda^{6/5}/H$, with H being the distance of the turbulence layer. With the recent advent of large-format, low-noise detector arrays it has now become possible to fully exploit these natural advantages of the $\lambda \geq 1\,\mu m$ wavelength range.

Several techniques have been employed for achieving high angular resolution in the near-infrared. Direct, long-exposure observations typically result in about 1″ resolution, but exceptional data with 0.5″ resolution have been reported in very good seeing. If individual speckles can be seen with short exposures, diffraction-limited images can be obtained (0.15″ at $2\,\mu m$ with a 3.5-m telescope). Various reconstruction techniques have been employed, ranging from the simple shift-and-add (SSA) algorithm (recentring each short exposure frame on the brightest speckle of a bright compact feature in the brightness distribution, Christou 1992) operating in the image plane, to the Knox-Thompson (Knox 1976) and triple correlation ("speckle masking": Lohmann et al. 1983) phase retrieval algorithms working in spatial frequency space. Interferometric techniques, such as non-redundant aperture masks (e.g. Haniff and Buscher 1992), have also been employed in single telescopes.

When the 256 × 256 pixel, low read noise (≤ 50 e), low dark current NICMOS 3 arrays (Rockwell International) became generally available in late 1989, we decided to put together a general-purpose, near-infrared camera for high-resolution imaging (50 milliarcsecond pixels and a 12.8 arcsecond field of view). To be able to continuously read out the array efficiently (duty cycle >70 % for the entire array at a frame rate ≤ 5 Hz and $2\,\mu s$ per pixel) and with high speed (up to 10 Hz for single quadrant [128^2]mode) we equipped the camera with 4 fast digital signal processors (DSPs), followed by a VMS computer system. This configuration allows on-line, quick-look data analysis (such as SSA) which has turned out to be exceedingly useful for getting a first impression of the quality of the data and for making decisions at the telescope. This is the concept of SHARP (System for High Angular Resolution infrared Pictures) which we then proposed to the ESO Director General, Harry van der Laan, to bring to the ESO NTT as a new (guest observer) facility. A central scientific goal with SHARP on the NTT has been (and continues to be) imaging of the central stellar cluster of the Galaxy for answering the key question of whether (or not) the Galactic Centre contains a massive black hole of about $10^6\,M_\odot$. If it does, SHARP should detect proper motions of stars in the central 2 arcseconds within a time period of about 6 years. Already SHARP's first observing run in August 1991 demonstrated the capability of the new instrument and delivered a ≈ 0.25″ K-band ($2.2\,\mu m$) image of the central 6″ which we reported in an earlier *Messenger* article (Eckart et al. 1991, see also Eckart et al. 1992). Subsequent observing runs delivered fully diffraction-limited (0.15″ FWHM resolution), H- ($1.6\,\mu m$) and K-band images with ≈ 350 stars in the central parsec (≈25″) and ≈40 sources within 2″ of the dynamic centre, thus

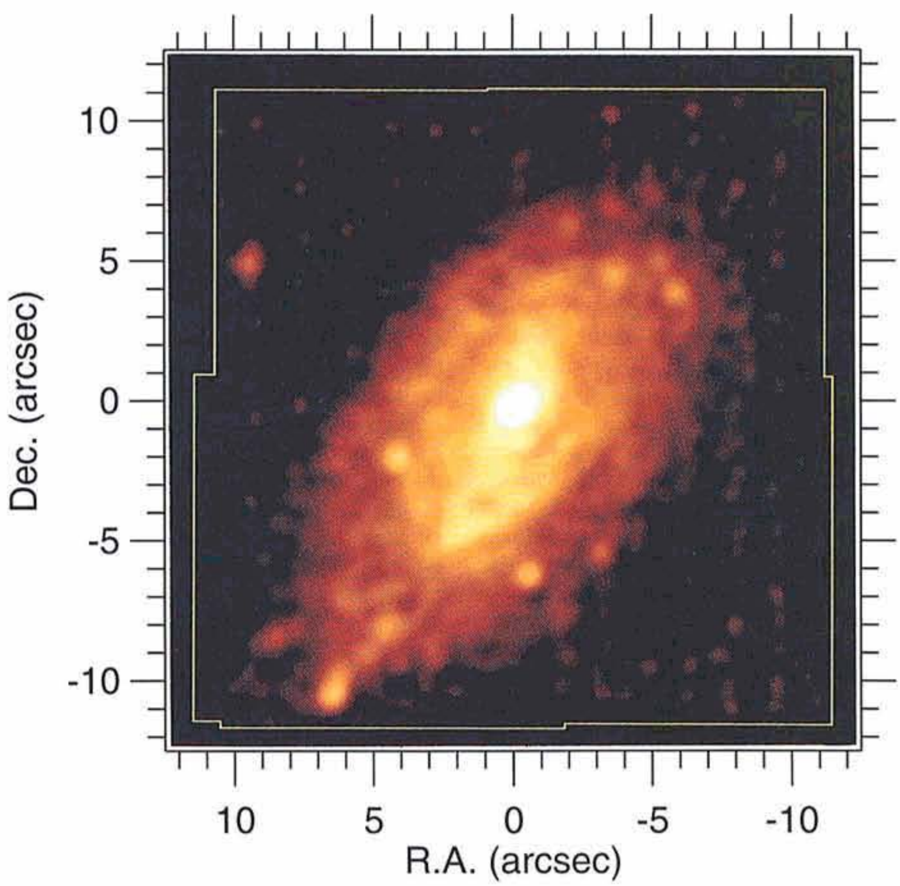

Figure 1: 0.6″ (FWHM) false-colour image of the K-band emission of NGC 1808 (Tacconi-Garman et al. 1994). The image is a mosaic of several frames and has been "Lucy"-cleaned, as described in the text. The colour table is logarithmic and the map borders (yellow lines) cover a 20″ field.

confirming the feasibility of the proper motion experiment. These results were obtained from a combination of the shift-and-add algorithm with a "Lucy" deconvolution (Lucy 1974) as a method of obtaining high dynamic range, "CLEANed" images (Eckart et al. 1993, Genzel and Eckart 1994). SHARP has also been employed for non-redundant mask, interferometric image reconstructions. First results have been presented in the last *Messenger* (Bedding et al. 1993).

In the present article we give an overview of the first extragalactic results that have been obtained with SHARP on the NTT.

Observing Extragalactic Nuclei with SHARP

The flux density sensitivity of SHARP is determined by the read noise of the array, RN ($\approx$ 50 electrons in read-reset-read mode). Given the overall quantum efficiency-transmission product of SHARP, $\eta \approx 0.2$, and broad-band operation ($\Delta\nu/\nu = 0.2$), the 10σ flux density sensitivity for observing a "point" source in integration time per frame t on the 3.5-m NTT ($A \approx 8.2$ m^2) is

$$\Delta S(10\sigma) \approx 14\, h\nu\, RN\, N_{pix}/(\Delta\nu\, A\, \eta\, t),$$

where N_{pix} is the number of pixels over which the flux of the point source is distributed. For 50 milliarcsecond pixels and 0.5″ to 0.7″ short-integration time seeing $N_{pix} \approx 100-200$. Hence, with $t \approx 1$ second, $\Delta S(10\sigma)$ without averaging pixels is about 15 to 30 mJy, corresponding to K-band magnitude 11.5 to 12.5. For integration times $t < 1$ sec, a fraction ε of the power is still in a diffraction limited (0.15″ FWHM at 2 μm) component so that the sensitivity of diffraction-limited imaging is about $1/\varepsilon \geq 10$ times worse than $\Delta S(10\sigma)$, resulting in limited magnitudes of 9 to 10. For non-diffraction limited operation the limiting sensitivity can be further improved by either somewhat larger pixels (planned for a future version of SHARP), or by averaging pixels, or by having better seeing (a matter of telescope design and location, as well as luck). In any case this consideration already indicates that a camera with a NICMOS 3 array on a 3-m-class telescope permits, for the first time, true subarcsecond near-infrared imaging as a relatively routine matter on a number of bright nuclei. As speckles are already smeared out for integration times of about 1 second or more, the method that is employed here should be called "rapid guiding" rather than "speckle" imaging. Typically a few 10^2 to a few 10^3 frames are coadded after recentring on the brightest feature in the map. This is followed by a step of Lucy-deconvolution (or another form of "CLEAN") to correct for the wings of the point-spread function (the "seeing pedestal"), using a nearby star as deconvolution key. As a "CLEAN"-restoring beam we use a Gaussian of FWHM resolution about the same FWHM resolution as the raw recentred data. As the image is very well sampled, a modest degree of super-resolution or image sharpening (say from 0.6″ to 0.4″, depending on the source brightness) can also be achieved without too much risk and has been done for the data sets described below. The final images then have a point source sensitivity to faint structures at least an order of magnitude lower than the limit given above ($\Delta S(1\sigma$, 15 min) ≈ 16 to 18).

So far we have observed over a dozen compact galactic nuclei. Here we present our results on the brightest sources (Table 1).

Observations of Starburst Nuclei

Figure 1 shows a 0.6″ FWHM resolution K-band mosaic (2 array settings, Table 1, Tacconi-Garman et al. 1994) of the central 20″ (1 kpc) of the "hot spot" galaxy NGC 1808 (Sersic and Pastoriza 1965). In addition to the bright nuclear source (about 20 mJy), the circum-nuclear 2 μm emission shows two arm-like features and a number of compact knots. The data strengthen the starburst interpretation of the infrared, visible and radio emission of the galaxy (Saikia et al. 1990, Krabbe, Sternberg and Genzel 1994). The circum-nuclear near-infrared continuum emission is globally well correlated with the radio continuum and Bγ emission-line knots found by Saikia et al. and Krabbe et al., indicating that much of the near-infrared continuum emission of NGC 1808 comes from a reasonably young ($< 10^8$ years) stellar component. In particular the arm-/ridge-like structure arching east and north of the nucleus show a very good overall correlation with the radio continuum and infrared line emission there. However, on the smallest scales probed by the maps, this correlation appears to break down, as local peaks in radio continuum, Bγ and in 2 μm continuum are slightly (0.5 to 1″) displaced from each other. The prominent compact knots 6″ north-west and 10″ south-west of the nucleus do coincide with two of the visible, blueish hot spots (Véron-Cetty and Véron 1983), but then others do not. These displacements may be the result of large, local spatial variations in extinction, although the average extinction on a scale of 2″ appears to be no more than $A_V = 6$ (Krabbe et al.). Alternatively and more likely, displacements between different tracers may be the result of time evolution, considering the spatially smooth J/H/K colour distributions. The 2 μm knots may be local concentrations of red or blue supergiants (typically a few 10^2 per knot) that may be signposts of the late evolutionary stage (a few 10^7 years) of giant OB associations. Given typical velocity dispersions in molecular clouds (a few km/s), separations of 1″ or more between H II regions (Bγ and radio continuum), supernova remnants (radio continuum) and supergiants are entirely consistent with age differences of a few 10^7 years. The observations thus suggest that the central kpc of NGC 1808 currently undergoes an active phase of star formation (total rate about 10 $M_\odot$ yr^{-1}) originating (at any time) in a number of giant H II regions/OB clusters. These giant star formation complexes are probably associated with molecular clouds, may live for about one generation of OB stars and are then replaced by others bubbling up elsewhere in the disk of the galaxy.

The SHARP maps of the nearby, luminous (4×10^{10} $L_\odot$, Rieke et al. 1980) starburst galaxy NGC 253 (Fig. 2, Table 1, Sams et al. 1994) teach another lesson. While this galaxy also shows a number of prominent near-infrared hot spots in its central 150 pc, it turns out that most of these spots are not actually physical entities but merely directions of lower local extinction in a highly obscured nuclear region (Sams et al. 1994). This is evident from comparing the maps at different wavelengths (Fig. 2). The longest wavelength (K-band) map is the smoothest, while the H- and even more the J-band map show an increasing amount of structure. Mm-interferometry of the CO 1-0 line (Canzian et al. 1988) indicates that the average H_2 column density in the central 8″ is about 3×10^{22} cm^{-2} ($A_V = 20$), consistent with the ex-

TABLE 1. *Bright Galactic Nuclei Observed with SHARP*

Galaxy	Distance [Mpc]	Number of Frames	t (Frame) [secs]	FWHM Resolution	Linear Resolution
NGC 253	2.5	300 (J/H/K)	5	0.5″	6 pc
NGC 1808	10.9	200–1000 (J/H/K)	4	0.6″	31 pc
NGC 1068	14	10300 (K)	0.5–1	0.2″–0.4″	14–27 pc
NGC 7469	66	5000 (K) 700 (J/H)	1–2	0.4″	130 pc

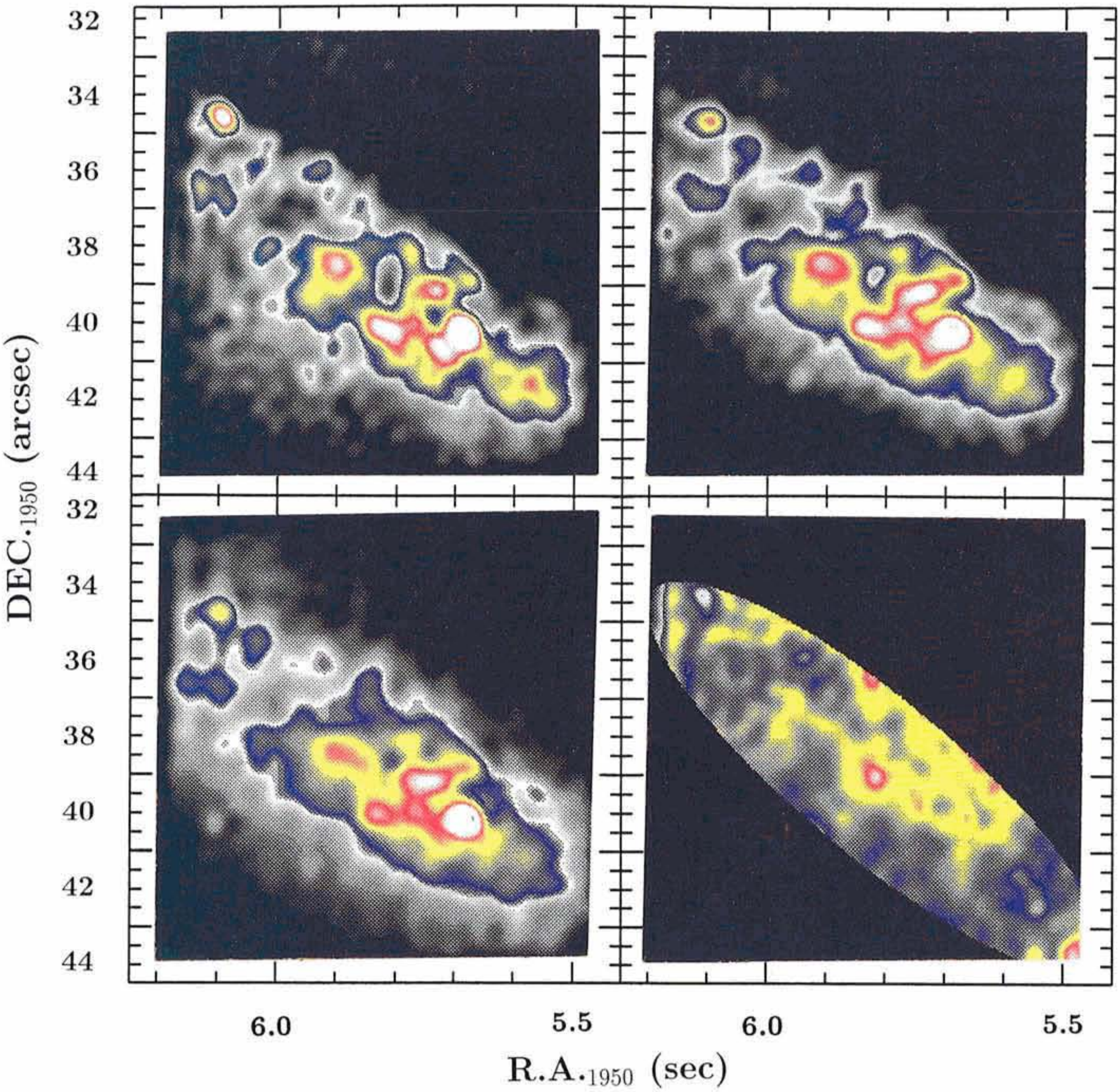

Figure 2: *0.5″ (FWHM) false-colour "Lucy"-cleaned images of NGC 253 in the J-band (1.2 μm, top left), H-band (1.6 μm, top right), K-band (2.2 μm, bottom left) and J-K colour (bottom right) (from Sams et al. 1994). Each tick on the Dec-axis is 0.5″, each tick on the R.A.-axis is 1.55″. The colour table is linear.*

tinction values required to explain the structure in the near-infrared continuum maps (Sams et al. 1994). While it is difficult to obtain detailed quantitative estimates of the dust extinction from the near-infrared data because of the uncertain relative locations of emitters and absorbers, the near-infrared colour map shown in Figure 2 is a good qualitative indicator of the (clumpy) spatial distribution of dust (and gas) on sub-arcsecond scales. Sams et al. find that the most prominent extinction peak (identical with the local "hole" of 1.2 μm emission 2″ north-east of the intensity maximum) is associated with the radio nucleus of NGC 253 and that the extinction map is globally well correlated with the radio map of Antonucci and Ulvestad (1988). In contrast to most other emission peaks on the near-infrared maps, the brightest K-band peak (≈ 15 mJy at K) does appear to be more than a direction of low extinction, namely a concentration of hot dust. Clearly, the effect of dust mixed with the stars may have an important effect on the near-infrared brightness distribution in a number of starburst nuclei, and near-infrared colour maps are a useful tool to detect and map out the absorbing dust.

Active Galactic Nuclei

Figures 3 and 4 show $\approx 0.4''$ resolution near-infrared maps of two of the active galactic nuclei that have been studied with SHARP, NGC 1068 and NGC 7469. For SHARP results on the Seyfert 1/QSO I Zw 1 see Eckart et al. (1994). The near-infrared emission from NGC 1068 (Fig. 3) is characterized by the bright (500 mJy at 2.2 μm, $\geq 1.5 \times 10^{11}$ $L_{\odot}$) Seyfert 2 nucleus, plus a stellar bar at position angle 45° extending to radii of about 16″ (1 kpc at 14 Mpc). The high-resolution data now suggest that at radii larger than about 7″

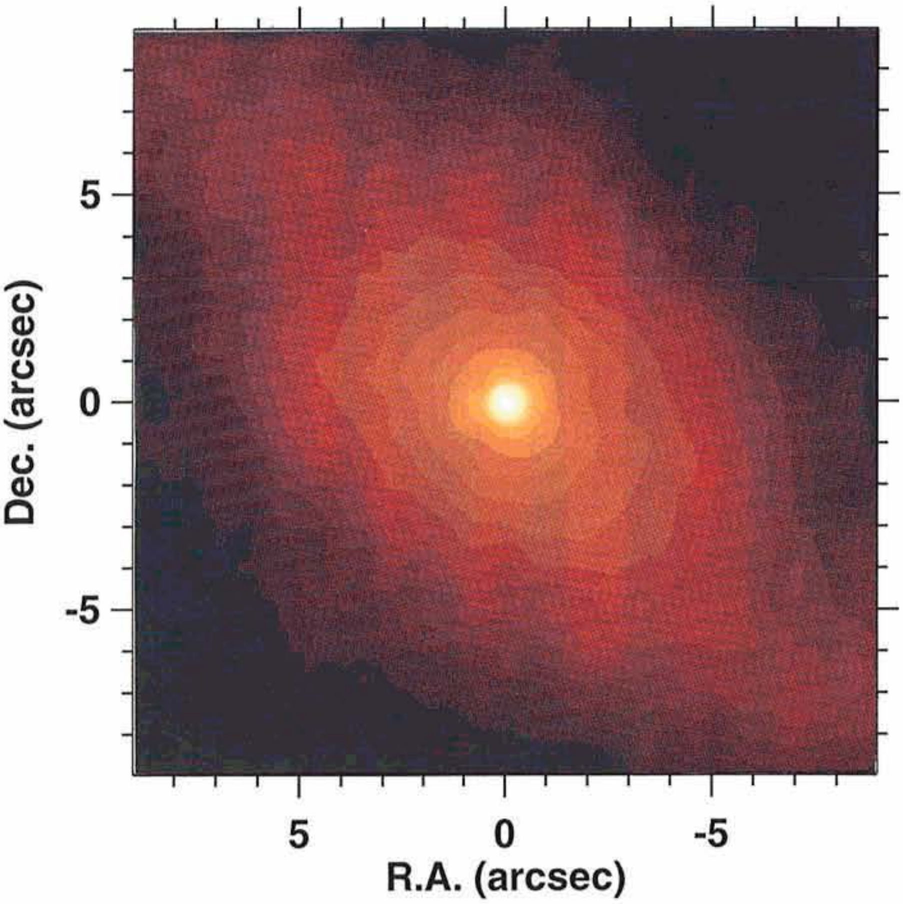

Figure 3: *0.4″ (FWHM) false-colour image of the K-band emission of the central (17.9″)^2 of NGC 1068 (from Quirrenbach et al. 1994). With the exception of the bright nucleus the map has not been "Lucy"-cleaned, in order to emphasize the faintest (K ≈ 17) extended structures. The colour table is logarithmic.*

the oval bar structure (minor to major axis ratio ≈ 0.7) turns into two arm-like features. This radius is coincident with the inner radius of the circum-nuclear gas/dust/star formation ring (e.g. Telesco and Decher 1988), suggesting an interpretation in terms of spiral arms that have formed at the inner Lindblad resonance near the end point of the bar. The high-resolution near-infrared data also probe the radial brightness distribution, and hence, the density distribution of the stellar light very close to the Seyfert nucleus. A first-order analysis of the Data in Figure 3 (Quirrenbach et al. 1994) suggests that the 2 μm stellar light may have an effective core (half peak intensity) radius of $r_c = 2 \pm 1''$. While the brightness distribution along the major axis (p.a. 45°) and minor axis (p.a. 135°) of the bar can be well fitted by a power law of exponent $\alpha = -0.95$ and -1.65, respectively, at $r > r_c$ the distribution very close to the nucleus appears to be significantly flatter. This is a fairly difficult measurement to make quantitatively, as the brightness of the stellar bar at r = 1″ is only $10^{-2.5}$ of the nuclear source. At face value this finding suggests that the 2 μm stellar light is dominated by the large scale (≈ 10^2 pc) disk/bar and that there is no bright, nuclear stellar cluster on a scale ≥ 30 pc. The SHARP data also confirm earlier proposals that the nuclear source has an intrinsic diameter ≤ 0.1″ (7 pc) and is dominated by hot dust emission. The J/H/K flux density spectrum can be described by a power law ($S \approx \nu^{-3.7}$). It is an interesting question for future research what the nature of this dust source is and whether it could be associated with the putative parsec-scale, dust/molecular torus. The near-infrared peak is displaced 0.4″ SW of the centroid of the visible emission (Gallais 1991). There is also a compact 2 μm H_2 line emission source at about the same position (Blietz et al. 1993) but mid-infrared imaging (Cameron et al. 1993) shows that most of the warm circum-nuclear dust is associated with the narrow line region.

While the extended emission in NGC 1068 is dominated by a bar-like structure, the Seyfert 1 galaxy NGC 7469 (≥ $3 \times 10^{11} L_\odot$) exhibits a ring. Figure 4

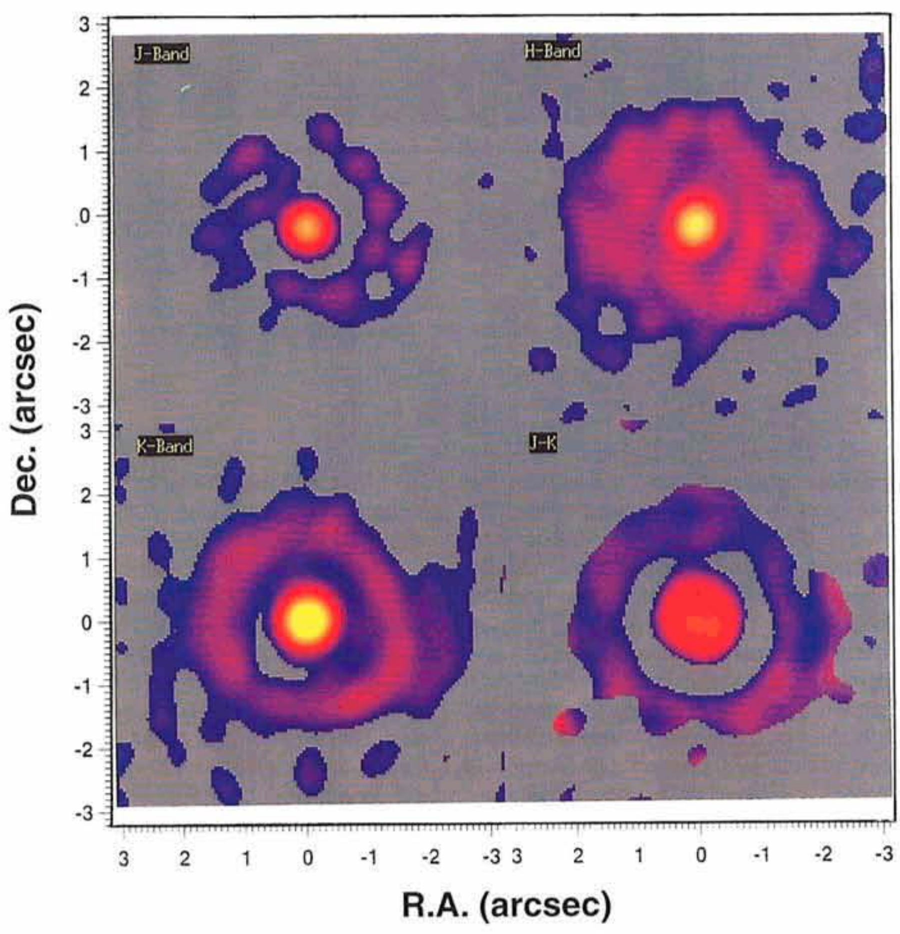

Figure 4: *0.4″ (FWHM) false-colour, "Lucy"-cleaned images of NGC 7469 in the J-band (top left), H-band (top right) and K-band (bottom left) emission, with logarithmic colour tables. The bottom right contains a 0.6″ (FWHM) J-K colour map (from Tacconi-Garman et al. 1993). Each image covers a 6.4″×6.4″ field.* *See also page 36 of this issue.*

shows the 0.4″ J/H/K SHARP images (Table 1), as well as a 0.6″ J-K colour map (Tacconi-Garman et al. 1993, Genzel et al. 1994). Outside of the Seyfert nucleus (90 mJy at K) there is a 1.5″ radius, ring structure with embedded knots. The colours of the ring are consistent with a stellar cluster reddened by $A_V \approx$ a few; in contrast, the very red nuclear colours suggest hot dust emission, as in the case of NGC 1068. The near-infrared images of Figure 4 are in very good agreement with similar resolution visible speckle images (Mauder et al. 1994) and with a VLA map of the 5 GHz radio emission (Wilson et al. 1991). All these data and ≈ 0.9″ near-infrared spectral line imaging with the MPE FAST spectrometer fit a model in which the ≈ 500 pc ring is powered by a luminous starburst forming about 50 $M_\odot$ of new stars per year for the last 1 to 3×10^7 years (Weitzel et al. 1994). One supernova explosion every two years is implied and may be detectable by means of time variability in the high-resolution near-infrared maps. The triggering mechanism for the circum-nuclear burst in NGC 7469 remains unclear as, in contrast to NGC 1068, the SHARP data do not show evidence of a bar structure. Perhaps the burst was triggered by the interaction of NGC 7469 with its neighbour, IC 5283.

The data we have presented in this report only represent a selection of a sample of about a dozen galaxies that have been observed so far with SHARP. We believe that this brief glimpse already demonstrates the power of the new tool of subarcsecond near-infrared imaging. The future is clearly bright.

Acknowledgements. We would like to thank Harry van der Laan for giving us the opportunity to bring SHARP to the right place at the right time.

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Infrared Spectroscopy of Galactic Globular Clusters

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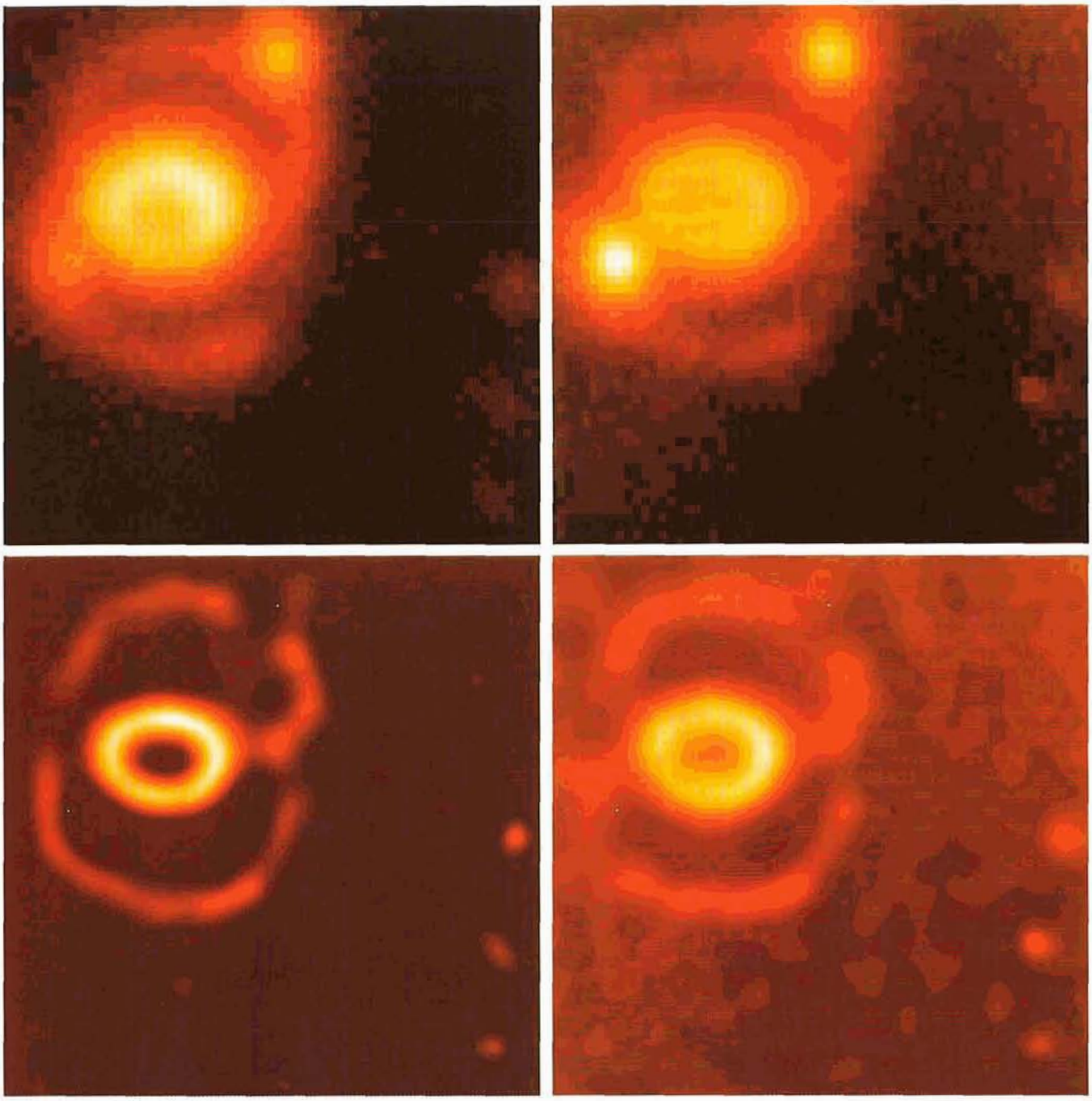
1. Introduction

Galactic globular clusters (GGCs) are the best templates for studying the physical and chemical properties of old stellar systems at different evolutionary stages. Zinn (1985) distinguishes two main subsamples on the basis of their spatial distribution, kinematics and metallicity; the halo system characterized by low rotational velocity and metallicity ([Fe/H])≤–0.8) and large velocity dispersion, and the disk+bulge system which is metal-rich ([Fe/H])>–0.8) and exhibits a large rotational velocity and lower dispersion.

From theoretical models (Renzini and Buzzoni 1986, Chiosi et al. 1986) it is expected that the integrated luminosity of old stellar populations is dominated by the luminous red giant branch (RGB) stars which are close to the He-flash. This scenario is largely confirmed by photometric and spectroscopic optical/infrared observations of the central regions and of the brightest single stars in many clusters (see for example Frogel et al. 1983a, b and references therein). The average temperature of this red and cool stellar component, i.e. the location of the red giant branch in the HR diagram, is directly related to the metal content of the cluster; the higher [Fe/H] the cooler the stars (Frogel et al. 1983b). Therefore, any temperature sensitive index (e.g. V-K, photometric CO) could, in principle, be used to determine the metallicity of globular clusters. The main limitations in the use of photometric indexes are extinction and contamination by foreground stars and both effects are particularly important when studying high metallicity clusters in the bulge. A way to overcome these problems is to use spectroscopic indices (which are intrinsically unaffected by extinction) in the infrared where the contamination from foreground stars is much less important than in the optical. We use two spectral indices in the infrared H band centred on SiI+OH 1.59 μm and CO(6-3) 1.62 μm together with the "classical" CO(2-0) 2.29 μm feature. These indices are good temperature indicators in cool stars (Origlia et al. 1993).

In this article we present integrated spectra of these features for a sample of GGCs and show that diagrams based on their equivalent widths can be used to tightly define the metallicity sequence from metal poor halo clusters to the most metal rich in the disk+bulge.

(continued on page 23)



New NTT Images of SN 1987A

H-α and N II λ6584 images of the nebulosities near SN 1987A that were taken by the NTT on December 19, 1993. H-α images are on the right and N II images are to the left. The upper image of each pair is the raw image while the lower is after deconvolution using the Lucy-Richardson image restoration technique (ESO preprint #975). All images are shown with a logarithmic intensity scale and they are oriented so that north is up and east is to the left. The CCD pixel size in the original image is 0.129 arcsec/px. The filter bandpasses were ~10Å and the wavelengths were centred to be correct for the redshift of the Supernova. The seeing for the N II image was about 0.7 arcsec (FWHM), and for the H-α image it was about 0.8 arcsec (FWHM). The resolution of the deconvolved image is ~0.2 arcsec (FWHM) for the N II image, and it is ~0.3 arcsec (FWHM) for the H-α image. In the deconvolved images the flux from star 2 (NW of the inner loop) and star 3 (SE of the loop) have been compressed into single pixels (white dots) at the locations of the star images. The deconvolution procedure produces some "ringing" around bright objects. In the deconvolved images, ringing caused by the inner loop and the two bright companion stars has caused breaks in the very faint outer loops and distortions in the intensity profile near the inner loop.

Note that in the raw N II image star 2 is much brighter than star 3, but that in the H-α image star 3 is much brighter than star 2. This is because star 3 is a Be star with strong H-α emission while star 2 has H-α absorption in its spectrum. The middle star in the line of three stars along the SW edge of the pictures is a close double. The intensity distribution of light around the inner loop is different in H-α from that of N II. Also, while the SE portion of the inner loop is now fading, the bright portions are now increasing in brightness (IAU Circular #5927). It seems likely that interactions between the expanding SN envelope and diluted gas within the inner loop are generating UV photons that are beginning to reionize the nebula.

L.-F. WANG and E.J. WAMPLER

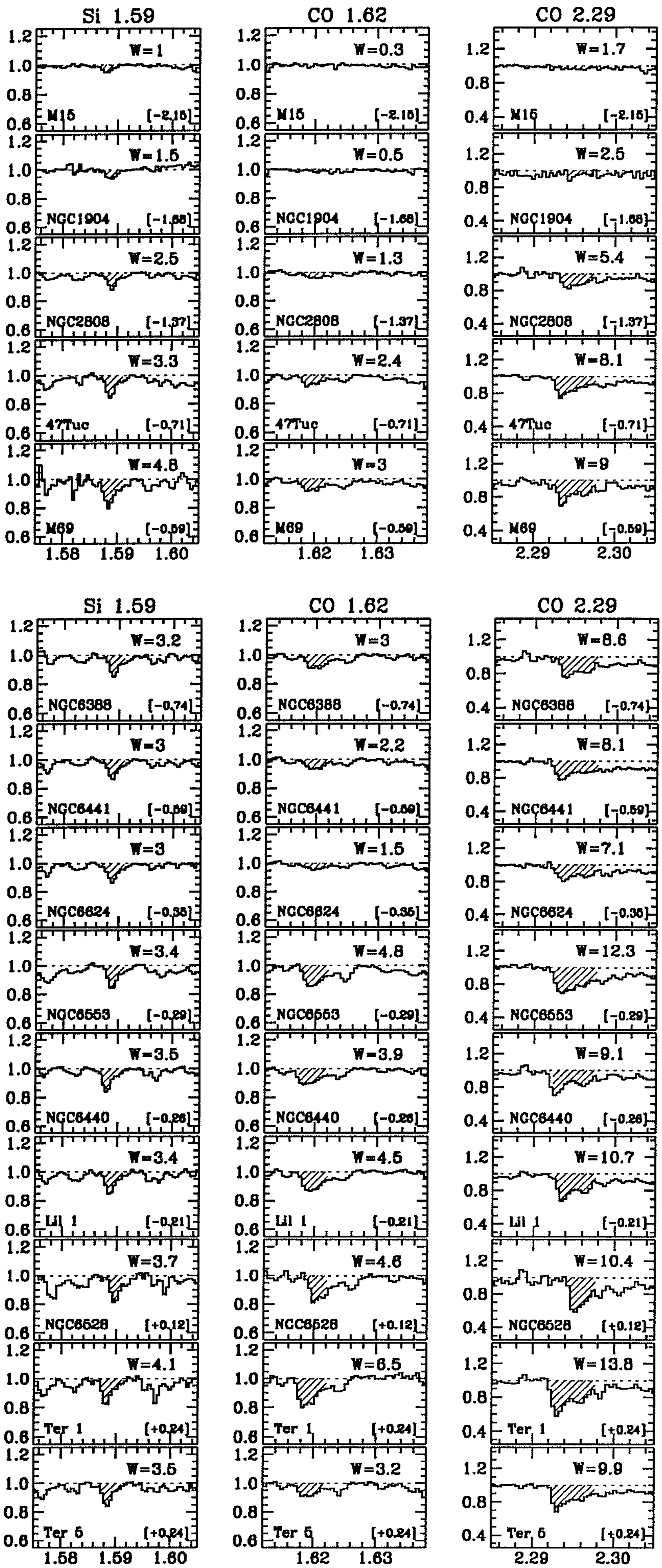


Figure 1: *Spectra centred at 1.59, 1.62 and 2.29 μm of the selected galactic globular clusters in the halo (top panel) and in the disk (bottom panel). The equivalent widths W are in Å and the metallicities are given in the lower right hand corners.*

2. Observations and Data Reduction

The data were collected during several observing runs (June 1991, November 1992, April and October 1993) at the ESO NTT telescope using the IRSPEC infrared spectrometer (Moorwood et al. 1991) equipped with a SBRC 62×58 InSb array detector. The pixel size was 2.2 arcsec along the slit and ≃5 Å along the dispersion direction yielding a resolving power R≃1500 with a 2 pixel (4.4″) slit.

Deep, long-slit spectra centred at 1.59 (Si I), 1.62 (CO 6-3), and 2.29 (CO 2-0) μm of a sample of galactic globular clusters in the halo and in the disk were obtained. The total average integration time was 16 minutes (sources+sky) for each grating position with automatic telescope beam switching every 2 minutes. The instrumental and atmospheric responses were corrected using reference spectra of featureless O5-6 stars. Data reduction was performed using the IRSPEC context of MIDAS and more details about IRSPEC reduction can be found e.g. in Origlia et al. (1993).

3. Results and Discussion

Normalized spectra of the central region (about 6″×4″ centred on the core) of the observed clusters are displayed in Figure 1. The shaded areas correspond to the measured equivalent widths in Å given on each spectrum which were computed using the procedure described in Origlia et al. (1993).

In Figure 2 we plot the measured equivalent widths in spectroscopic equivalents of colour-magnitude diagrams, i.e. 1.62 vs 1.62/1.59 and the 1.62 vs 1.62/2.29.

In these diagrams the clusters are distributed over the loci defined by giant stars (cf. Fig. 5c Origlia et al. 1993). The warmer and less metallic systems are at the bottom left while cooler and more metallic ones progressively move up and to the right. There is general agreement between the metallicities given in Figure 1 (taken from Zinn 1985) and the trend in Figure 2 but with a few remarkable exceptions: Ter 5 ([Fe/H] = +0.24, the highest value in our sample) appears to be much warmer than NGC 6440 ([Fe/H] = −0.26) and other clusters of lower

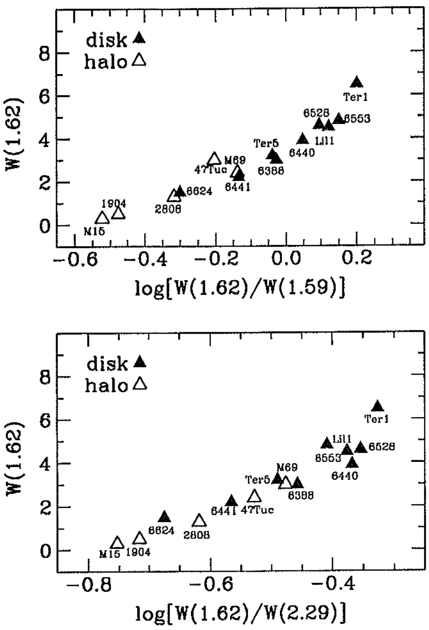


Figure 2: *Spectroscopic 1.62 vs 1.62/1.59 and 1.62 vs 1.62/2.29 colour-magnitude diagrams.*

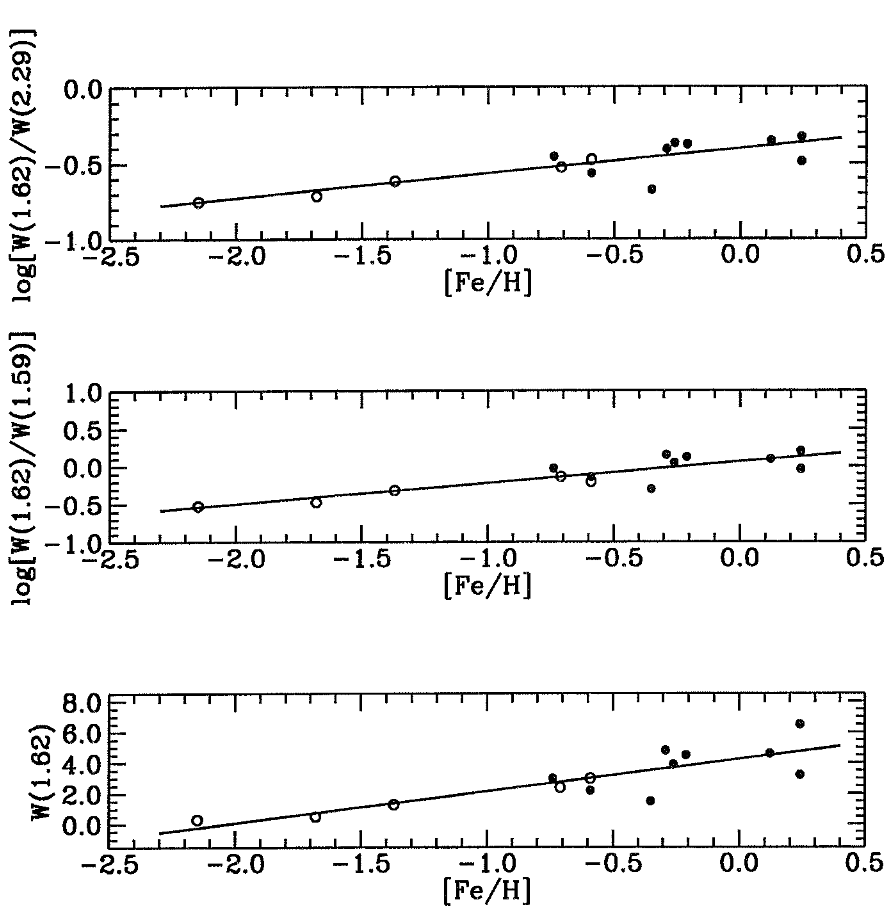


Figure 3: *Correlation between the 1.62, 1.62/1.59 and 1.62/2.29 indices with the metallicities reported by Zinn (1985). Open circles are the halo clusters and filled ones are the disk+bulge clusters.*

metallicities while NGC 6553 ([Fe/H] = −0.28) seems to be as cold as clusters with [Fe/H]>0 (NGC 6528, Lil 1). Unless this is due to large anomalies in the C/Fe and Si/Fe abundances, this probably demonstrates that our IR indices provide a more precise measurement of [Fe/H] in high metallicity systems. The same conclusion can be drawn from the plots of spectroscopic indices versus [Fe/H] in Figure 3 which show a scatter at large metallicities which is considerably in excess of the measurement accuracy.

We are now studying the possible effects of C/Fe and Si/Fe anomalies using synthetic spectra based on model stellar atmospheres before producing a precise metallicity scale on diagrams like those in Figures 2 and 3.

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Probing Dust Around Main-Sequence Stars with TIMMI

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The search for extra-solar planetary systems is a fascinating challenge. Direct imaging of such planets is hopeless, at least nowadays, so that efforts have been focused on looking for possible effects induced by a planet on its host star, such as faint modulation of the apparent flux (Paresce 1992 and references therein) or modulation of the apparent period in case of pulsars (Wolszczan and Frail 1992); but these searches are difficult. Since the discovery by IRAS in 1984, that many main-sequence stars are surrounded by dust (Aumann et al. 1984, review by Backman and Paresce 1993 and references therein), it has been recognized that gravitational perturbations of dust orbits by a planet could result in large modifications of the dust structure, such as voids of matter in the region inside the planet orbit or asymmetries (for example, Roque et al., in press). That is why many telescopes have been pointed towards main-sequence stars with IR excess, in an attempt to image the dust responsible for the excess.

Up to now, only the dust around the β-Pictoris star has been unquestionably imaged, thanks to visible observations (Smith and Terrile 1984). The dust was shown to be in a disk-like structure. But even with sophisticated techniques, using coronographic adaptive optics or antiblooming CCDs, the region inside a radius of 2.5″ (40 AU at the distance of

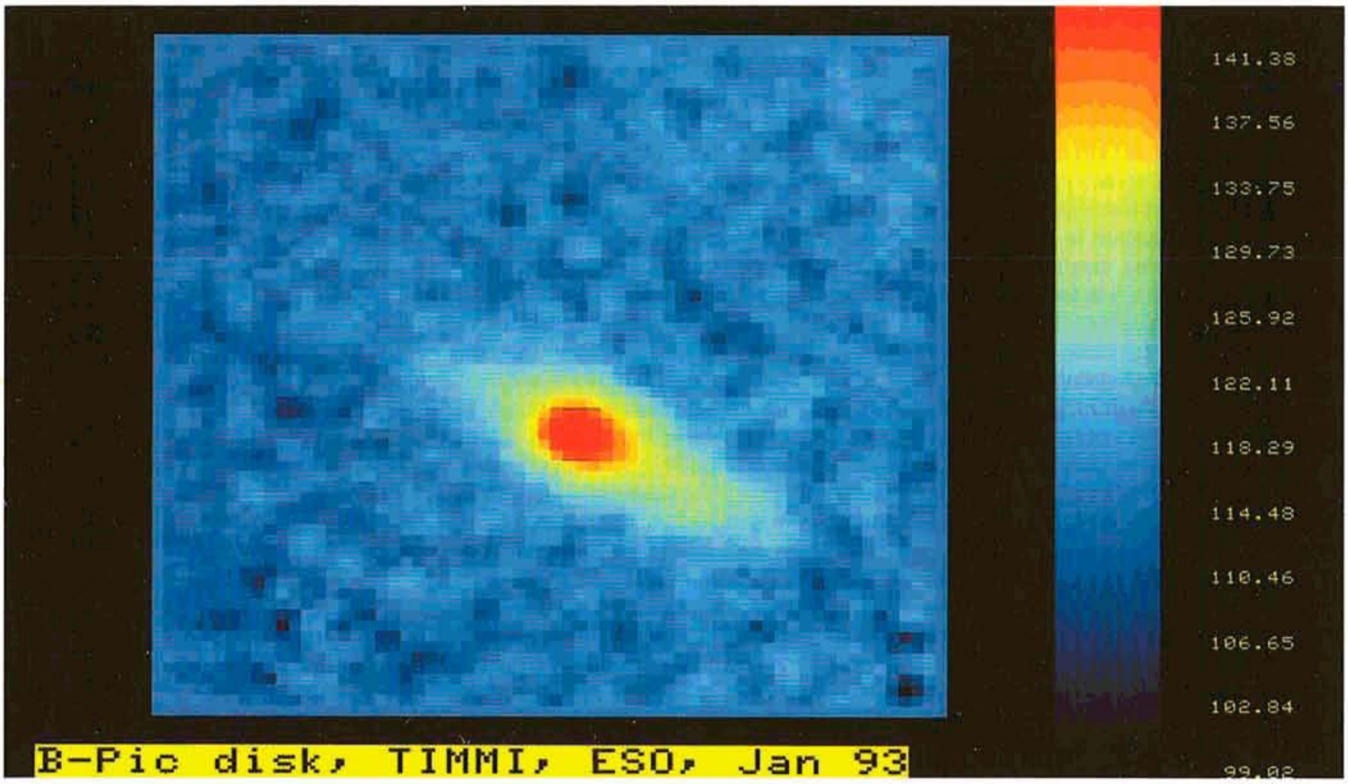

Figure 1: *β-Pictoris dust disk as observed at 12 μm with TIMMI (see also Lagage and Pantin, in press). The pixel field of view in use was 0.3″, corresponding to 5 AU at the distance of β-Pic (16.5 pc) and the total field is about 20″×20″. East is at the top, north on the left; the colour scale is logarithmic. The star contribution (of the same order as the disk contribution) has been removed; but the image shown here has not yet been deconvolved from the point spread function (full width half maximum of 0.9″).*

β-Pic, 16.5 pc), where traces of planets are expected to be present, has been inaccessible so far (Lecavelier des Etangs et al. 1993, Golimowski et al. 1993). The problem with visible observations is too high a contrast between the central star and the dust disk emission, which originates from scattering of the star radiation.

In the Mid-Infrared domain (MIR) the situation is quite different. Indeed, the radiation at these wavelengths originates from thermal radiation of grains, which reprocess a small fraction of the visible radiation into the mid-infrared domain, where the photospheric emission of the star is much fainter than in the visible. For example, at 10 μm, the dust contribution and the star contribution in the β-Pic system are of the same order, so that it is possible to remove the star contribution and to obtain the disk structure down to the diffraction limit of the telescope (0.7″ for a 3-m-class telescope). By using appropriate deconvolution techniques, we can even expect to go beyond the diffraction limit.

To achieve the diffraction limit in the MIR, we had to await the recent developments of monolithic detector arrays (although the scanning technique allows, in principle, for high angular resolution with monodetectors, such observations are difficult and consume a lot of telescope time). ESO has recently acquired a 10 μm camera, TIMMI, equipped with a detector array manufactured at the LETI/LIR, CEN Grenoble. This camera was built under an ESO contract, by the Service d'Astrophysique (SAp) at Saclay, which had already developed two other ground-based 10 μm instruments: C10μ (Lagage et al. 1993a), in collaboration with the Observatoire de Lyon, and CAMIRAS (Lagage et al. 1993b); both in use in the northern hemisphere. The TIMMI camera has now started its scientific life, as shown below. Technical details on TIMMI can be found in the papers by Lagage et al. 1993c, and Käufl et al. 1994.

We observed β-Pic with TIMMI at the 3.6-m telescope during 5 half nights at the beginning of January 1993. Two nights were useless, because of too variable a seeing. Only about one hour was lost for technical reasons. (After moving the f/36 rotator to align the disk with one of the axes of the array, the guiding had lost the north! This software problem is now fixed.) The final image obtained through the 10.3 – 13 μm filter and the smallest pixel field of view (0.3″), is shown in Figure 1; the on-source integration time is 75 min, spread over 3 nights, corresponding to a total observing time of about 200 min (the increase in time originates from the observing technique; no loss is due to the acquisition system, even with a flow of data as high as one 14 bit pixel every μs!). The observing technique used to remove the huge photon background generated by the telescope and the atmosphere (10^6 times brighter than the faintest signal detected in the β-Pic disk) is the standard chopping (moving of the secondary mirror at a frequency of a few Hz) and nodding (moving the telescope every minute) techniques. The only little trick is that the mirror chopping frequency is half the effective sky chopping frequency (AABBAABB . . . instead of ABABABAB . . .). The nearby (a few degrees) α-Car star was used both as photometric reference and as point spread function reference; the full width half maximum was measured to be of 0.9″, close to the diffraction limit.

The image of Figure 1 confirms without ambiguity the previous claims that the β-Pic disk is extended at 10 μm (Telesco et al. 1988, Backmann et al. 1992); the extension is observed up to more than 4″ from the star. Then, these observations definitely dismiss the models with large grains (> 10 μm), which, at 4″ from the the star, would have a blackbody-like temperature of 70 K, too low to be observed at 10 μm. Another interesting feature is the morphology of the disk, which appears asymmetric. The asymmetry seems too wide in size to be due to the emission of a cold companion, but could be accounted for by the presence of a planet on a slightly excentric orbit, able to generate arc-like structures in the dust disk (Roque et al., in press). The other possible dust trace generated by a planet, a void of matter, is not apparent on Figure 1. But the brightness of the disk seen on Figure 1 is (schematically) the result of 2 parameters: the dust density number and the dust temperature. Modelling the dust temperature, we found a temperature induced brightness gradient steeper than observed, so that a deficiency of matter towards the star is needed, even if the brightness is still increasing (Lagage and Pantin, submitted).

Note that thanks to the Richardson-Lucy deconvolution algorithm, we were able to resolve the disk structure at the level of one pixel. That means that a better sampling of the diffraction pattern would make sense. An improvement in this direction could be easily achieved by upgrading TIMMI with the new 128×192 Si:Ga detector array under manufacturing at the LETI/LIR (Lucas et al., in press) and whose pixel size will be of $75 \times 75 \mu m^2$, instead of $100 \times 100 \mu m^2$ for the actual detectors. Note also that the reference for the point spread function has to be taken not too far away from the object, because the aberrations (decentring coma . . .) of the 3.6-m telescope in the f/36 configuration, of the order of 1″, depends on the telescope position (Gilliotte, private communication).

Another promising candidate to image in the MIR is 51 Oph. Indeed, the 10 μm emission from this object is large (10 Jy) and almost entirely due to thermal radiation of dust (Coté and Waters 1987). Furthermore, from similarities between the gaseous optical and ultraviolet lines detected around β-Pic and 51 Oph, it was concluded that the 51 Oph dust was probably in a disk-line structure seen edge-on, like the β-Pic structure (Lagrange-Henri et al. 1990, Grady et al. 1993), which makes the detection easier. But the object has the disadvantage of being far away from us (70 pc). Nevertheless, given the size of the β-Pic disk observed, it was worthwhile trying to image the 51 Oph dust. The observations were conducted in June 1993. After data analysis, we were able to image a dust envelope . . . but that of α-Sco, the reference star! This observation is encouraging for the programmes aiming at studying the dust around late-type stars (Mékarnia, private communication); but this is another subject. Fortunately, we always observe two reference stars; the second reference star was point-like. Oph 51 also appears point-like; nevertheless, the negative result led to interesting constraints on dust disk models (Pantin and Lagage, in preparation).

We have now observed all the few main-sequence stars of the southern hemisphere with a large 10 μm excess. (The last data, obtained in December 1993, are not yet fully reduced). We are now observing stars with a much fainter excess, but which are nearby, so that we can still expect a detection. However, for two reasons the best window for detecting new disks is not the 10 μm window, but the 20 μm window, even though it has a poorer atmospheric transmission than the 10 μm window: first, most of the star disk candidates exhibit a sizeable excess only beyond 10 μm (Aumann and Probst, 1991); second, the 20 μm radiation is emitted by grains twice cooler than the grains detected at 10 μm; these grains are at least 4 times more distant from the star, which is more than enough to compensate for the loss in diffraction-limited angular resolution. The 17 μm channel of TIMMI, with a sensitivity more than an order of magnitude worse than expected for a good 20 μm camera, is of no help for the kind of programmes discussed here. The weather conditions at La Silla may not be good enough to justify an ESO investment in a 20 μm camera. On the contrary, Paranal is a promising site for 20 μm observations, so that a 20 μm channel is an indispensable complement to the 10 μm channel of the Mid-Infrared instrument under study for the VLT. We can anticipate a large use of this window for all the programmes dealing with dust around stars, whatever their evolutionary stage: young, main-sequence or late-type.

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NTT Observations of Obscured Globular Clusters

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The bulge of our Galaxy contains a number of globular clusters hardly observable due to the high obscuration close to the direction of the Galactic centre. At the Galactic plane, the extinction may amount to more than $A_V = 30$ magnitudes. A few clusters and fields located in regions of low extinction (or "windows"), such as the Baade Window, have been known for some time and can be easily observed. More recently, however, a number of very ob-

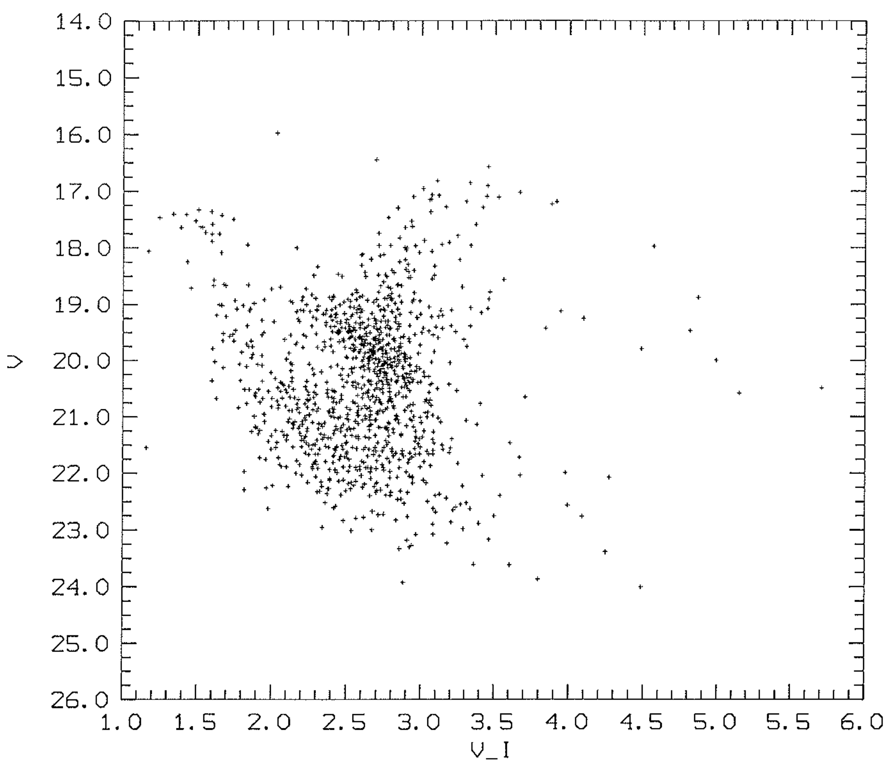

Figure 1: *V vs (V-I) Colour-magnitude diagram for Palomar 6.*

scured clusters could be identified, and colour-magnitude diagrams (CMDs) can be built using near infrared bands like, e.g., I and Gunn z (which are less affected by interstellar reddening) combined to sophisticated technology available at the NTT. The study of these clusters is important because they are possible tracers of the bulge population.

Such is the case of Liller 1, a very obscured globular cluster, discovered by Liller (1977) as the optical counterpart of the X-ray source MXB 1730-33. It is seen projected very near to the galactic centre direction at galactic coordinates l=354.81°, b=−0.16° and an inspection of the ESO R plates shows that it is among the faintest known globular clusters or globular cluster candidates in the Galaxy.

Another example is shown in Figure 1, where the V vs (V-I) CMD for Palomar 6 is shown, to be compared with a previous diagram obtained by Ortolani (1986) from observations with the Danish 1.5-m telescope. Using the NTT telescope, we could reach the giant branch and horizontal branch of this cluster (at V=19.7 and V-I=2.7), while only the red giant can barely be seen in the previous diagram.

The new observations were made at the red arm of EMMI. A LORAL front-illuminated CCD (ESO # 34) with a pixel size of 15 μm (0.35″) was used. The CCD array has 2048×2048 pixels, from which only the central 500×500 were extracted and reduced. Notice the improved quality of the new results. The photometric quality is better and the diagram deeper. This is due mainly to the high optical quality of the NTT images, even if the seeing at the time of the observations of Pal 6 was not excellent (around 1″ FWHM). This is, however, much better than our previous 1.6″ best value obtained at the Danish telescope. Also the reduction techniques contribute to the improved results. The relatively new Daophot II and Allstar codes, installed in Midas in 1991, were used for our new fields. These reduction programmes are much better than the "old" Daophot I, mainly because of the more accurate treatment of the mathematical deconvolution of crowded stellar images and the improved point spread function (which is the mathematical function of the stellar shape). From the features of our new diagram it can now be verified that Pal 6 is in the class of bulge metal-rich globular clusters (Ortolani et al. 1990, 1992). Pal 6 has a reddening $A_V \approx 4.3$ magnitudes and can be studied in the V band.

Liller 1 was observed during the same observing run and reduced with the same technique. It is so heavily obscured that its brightest giants are at the detection limit in V. Clearly, for this kind of globular clusters, the observations must be shifted to bands farther in the red. Indeed we have been able to study the CMD of Liller 1 in I and Gunn z with the NTT and the above-described equipment. The results are shown in Figure 2 for a circular extraction of r < 35″ centred on Liller 1. The z magnitudes are instrumental. The giant branch is clearly detected and the CMD reaches the horizontal branch level at I=19.9. The giant branch indicates a very metal-rich cluster, because

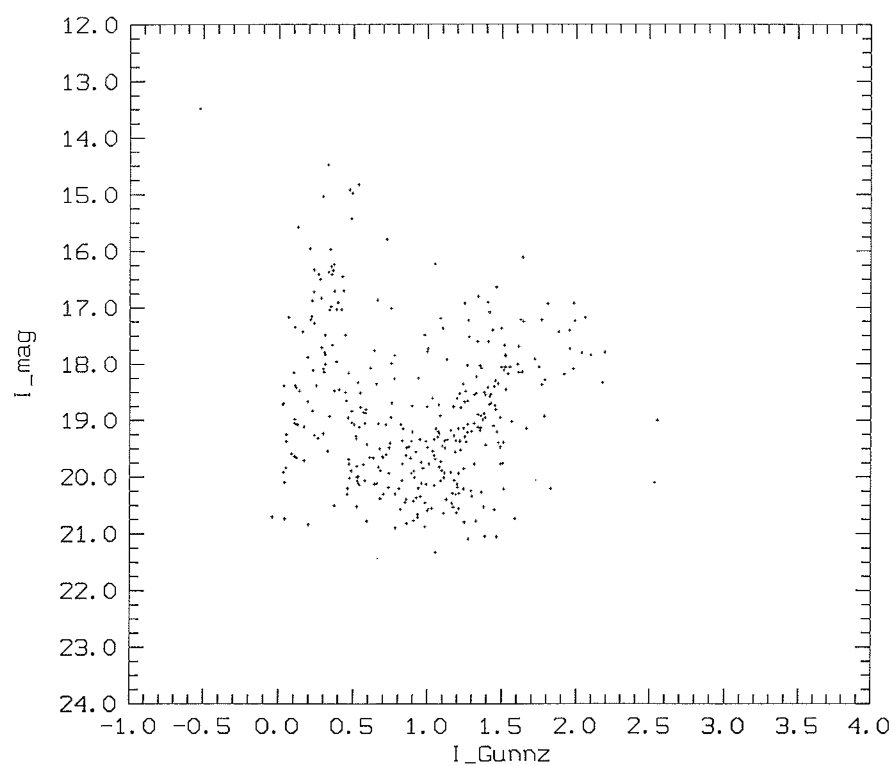

Figure 2: *I vs (I-z) Colour-magnitude diagram for a circular extraction of r < 35″ centred on Liller 1. The z magnitudes are instrumental.*

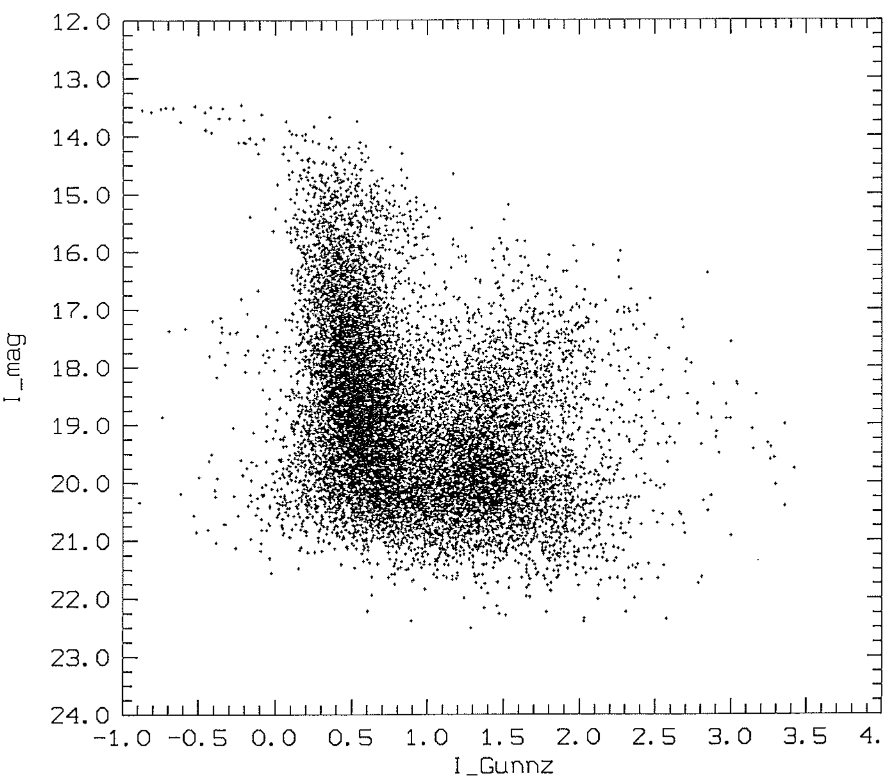

Figure 3: *Colour-magnitude diagram for the field near Liller 1, of size ~ 10′×8′ containing 20,000 stars.*

metallicity effects are seen also in these near-infrared bands, which otherwise are little affected by blanketing in less metal-rich clusters.

Another important result can be seen in Figure 3 where we show the CMD for the whole field of size ~ 10′×8′ containing about 20,000 stars, which is provided by the present equipment. In addition to the strong main sequence, the bulge field GB and HB are observed. Note the similarity of the latter component, in terms of values and morphology, to Liller 1. We conclude from this similarity that Liller 1 is located at the distance of the bulge bulk stellar population (close to the Galactic centre) and present similar metallicity. An interesting future project would be high-resolution spectroscopy of giant members for better metallicity determination of stars in the inner bulge. As such stars have I ≈ 18 magnitudes, one clearly will need telescope apertures such as that of the VLT. New, direct image observations in the cores of these clusters are also planned with the WFPCII of Space Telescope.

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Fine Structure in the Early-Type Components in Mixed Pairs of Galaxies

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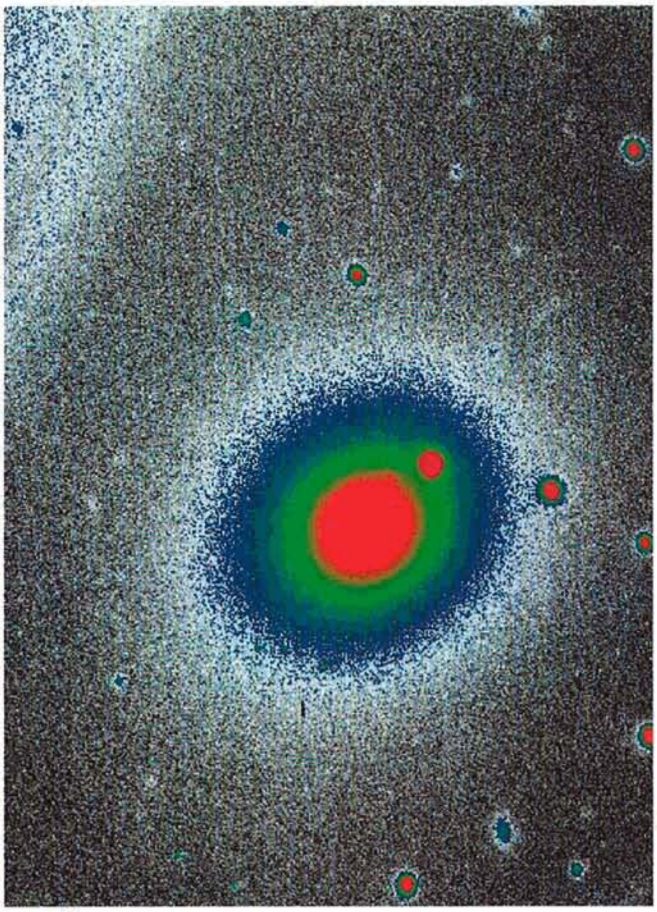
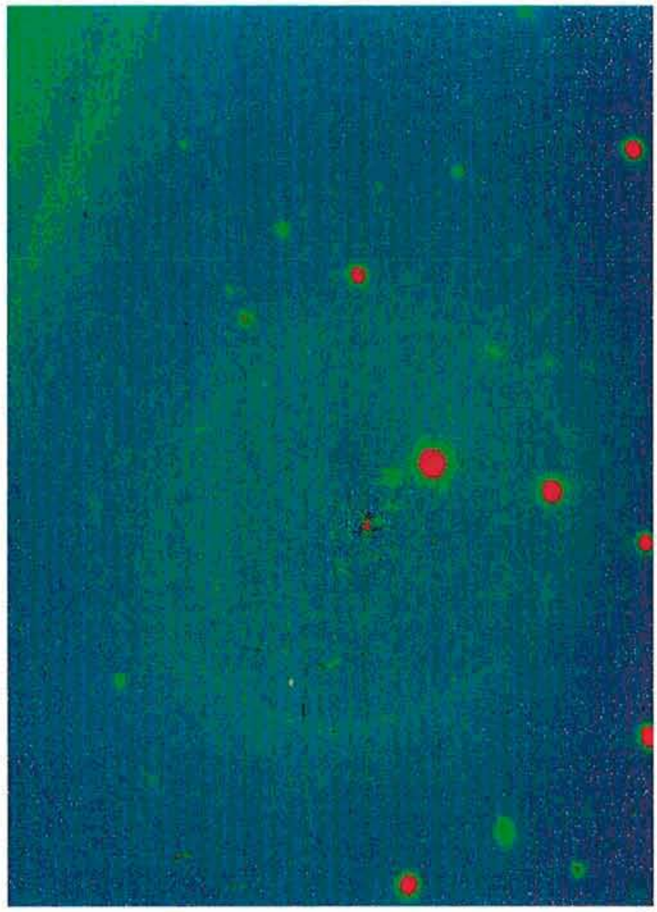
Elliptical galaxies were once viewed as the simplest of the forms assumed by stellar aggregates in the universe. Many observational discoveries in the past 15 years have altered this simple viewpoint. Both kinematic and morphological complexities are rapidly becoming the rule rather than the exception when ellipticals are studied closely. We describe here a new observational study of fine structure in elliptical members of binary galaxy systems. The structure is not always obvious in raw images because the smooth contribution from the stellar component is so strong. We consider techniques for enhancing these clues into the structure and evolutionary history of elliptical galaxies.

I. Introduction

One of the competing explanations for the origin of (many or all) elliptical galaxies views them as merger products. Fine structure, such as the shells, ripples and X-structure observed in many ellipticals, is considered by some as evidence for merging/accretion events. An objective definition of what constitutes a merger product must await a better understanding of the phenomenon and its frequency of occurrence. Even allowing for a large uncertainty in the numbers, it seems that a link exists between observed fine structure and other suspected signatures of past interaction, such as kinematically decoupled cores, unusual UBV colours and X-ray emission.

We are interested in the structure of E/S0 galaxies that are paired with spiral galaxies in so-called mixed morphology pairs. The existence of physical pairs of mixed type was questioned until recent optical and FIR studies showed that considerable numbers must exist. We are interested in comparing the properties of galaxies in such pairs with isolated galaxies of similar morphological type. We are searching for evidence that the morphology difference of galaxies in mixed pairs might be due to secular evolutionary effects related to periodic encounters with the close companion. If many of the structural peculiarities now





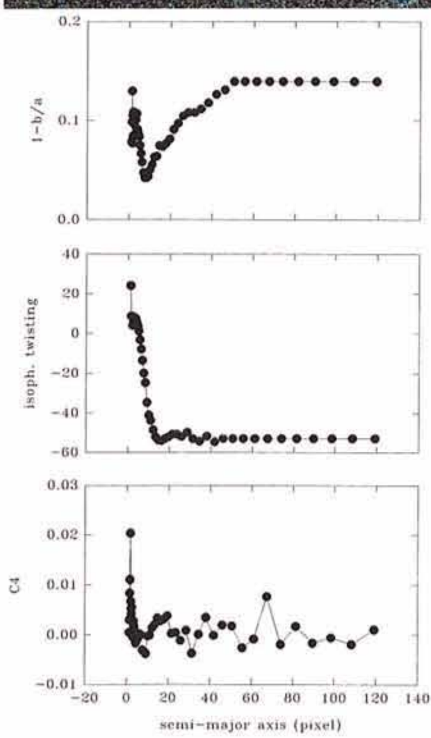


Figure 1: *(Upper left) Original image of E506-01 (B_T = 13.28). This galaxy (with cz = 3275 km s^{-1}) is paired with the spiral E506-02. (Upper right) E506-01 with model subtraction. No substructure is observed. (Left) Radial variation of ellipticity, twisting and isophotal shape derived from the model used in the above subtraction.*

found in ellipticals can be ascribed to interaction, then we might expect an even greater frequency of occurrence in binary systems. The problem is, of course, detecting and enhancing such fine structure.

We adopt a modelling technique in order to study the fine structure in the early-type components of mixed pairs. A galaxy is modelled using the photometric and geometrical information obtained from an isophotal fitting algorithm. We find that the frequency of occurrence of shells and X-structure appears to be lower than that found in a sample of relatively isolated ellipticals (Schweizer 1992). A true deficit may imply that pairs undergo fewer low mass accretion events or that fine structure is destroyed rather than created by interaction.

II. The Sample

Our primary sample of mixed pairs was selected from the southern sky using criteria similar to those employed in compiling the CPG (Karachentsev 1972; Sulentic 1989). The original sample was extracted from the Lauberts and Valentijn (1989) catalogue. The working sample includes pairs of galaxies that are isolated and that show a maximum component size ratio of four to one. The IRAS detected members of the southern sample with known redshift have also been observed in CO with SEST (Combes et al. 1993). The enhanced FIR and CO emission detected in that sample gives us confidence that we are dealing with physical binaries and multiplets. We have recently supplemented our southern sample with 168 northern mixed pairs that were imaged at KPNO by N. Sharp and JWS.

We have imaged 16 of the southern mixed pairs (and 3 early-type pairs) with the 90-cm ESO-Dutch telescope at La Silla (Chile) through B, V and R Bessel filters. We used a 512 × 512 CCD (# 33) with 27 μm pixels and a scale of 0.44 arcsec px^{-1}. Typical exposure times were 10 min in R, 20 min in V and 45 min in B. A set of standard stars was observed for photometric calibration. Combined with a previous sample (Rampazzo & Sulentic 1992) observed with the 2.2-m ESO telescope we now have imaging data for a total of 41 pairs which include 45 early-type galaxies. The 2.2-m sample was taken from a mixed pair catalogue compiled by one of us from visual inspection of the ESO/SERC sky survey. Only three of the pairs

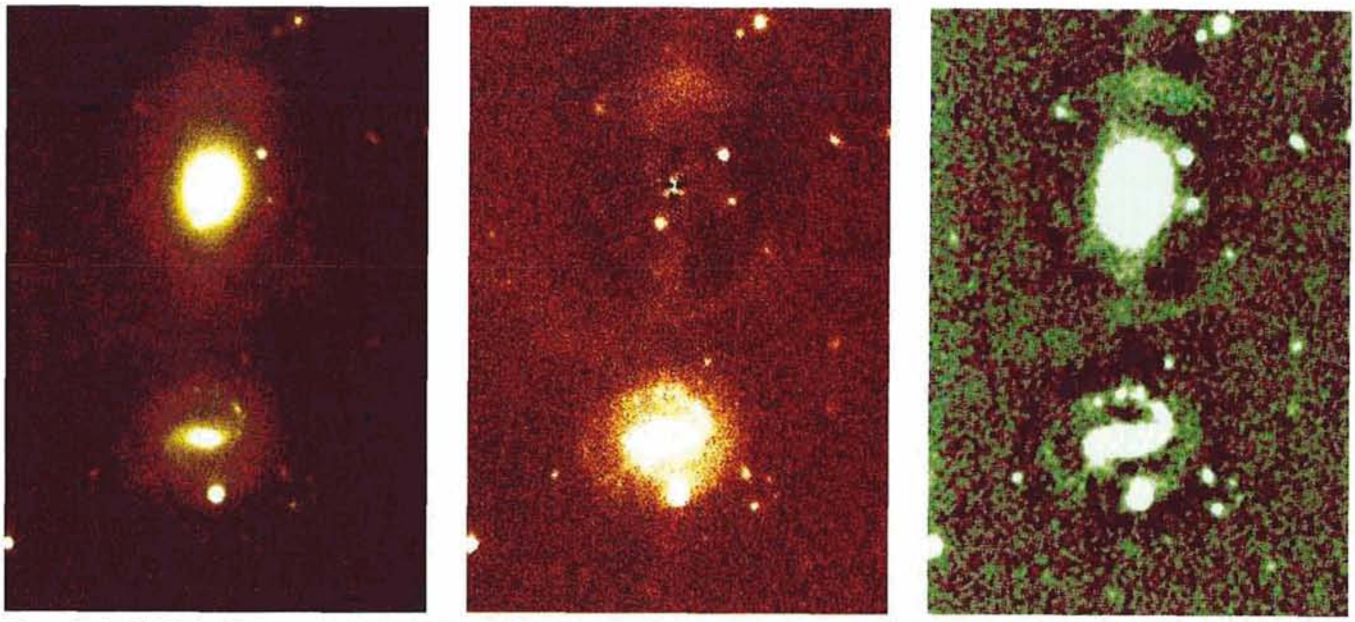


Figure 2: *(Left) Original image of AM 2312-511. (Middle) The pair after model subtraction. (Right) The pair after subtraction from the original image of a 69×69 pixel low pass model (with 5×5 pixel boxcar smoothing).*

with known redshift are above 10,000 kms^{-1}. A complete photometric analysis is in progress but we want to report here on the search for substructure in the early-type components.

III. Fine Structure Detection

Fine structure near the centre of an elliptical galaxy is usually many orders of magnitude less intense than the stellar component. The essential secret to revealing and enhancing it involves an understanding of the spatial frequency distribution in an image. If we were to take the 2D Fourier Transform of an image, we could represent the spatial frequency content of an image by its power spectrum. White noise dominates at the highest frequencies while galaxy structure and large scale background variations dominate the low and intermediate frequencies. Flat fielding will remove most of the instrumentally induced background variations. Removal of the low spatial frequency galaxy component in the Fourier domain would involve filtering or weighting the power spectrum so that the low frequencies are removed or underrepresented. Retransformation into real space will yield an image displaying only higher spatial frequency structure (if it is present). Filtering in the Fourier (linear spatial frequency) domain is not a trivial task however. Modification of the power spectrum usually results in the introduction of unwanted artifact that greatly complicates interpretation of the data. It is almost always preferable to use filter or modelling tools in the non-linear real space domain rather than in the Fourier

TABLE 1. *Early-type member of pairs showing structures*

Ident.	Other ident.	Type	B_T	1	2	3	4	5	Notes
AM2312-511		E	15.7	•				•	
AM2353-192	E471-471	E	14.69		•			•	Tidal
	E471-470	S0	15.16		•				origin
AM0106-285	E412-07	E	13.5	•					
		SB0/a	14.3	•					
	E541-240	S0	15.18				•	•?	One
	E541-241	S0	17.02						distorted
AM1754-634	E102-20	E	13.2				•		Small central
									disk
AM1806-852	E010-01	E	13.37				•	•	
AM2019-442	E285-04	E/S0	14.42				•	•	
AM2144-551		E/S0	14.5		•		•		Uncertain
AM2154-382		SB0/a	15.1	•			•	•	
	E511-31	E/S0	14.26				•?	•	Uncertain
	E187-23	S0	12.92				•	•	
AM1440-241	E512-18	E/S0	12.96		•		•		S0+Spiral
	E386-04	E/S0	13.74	•			•		
	E360-11	S0	15.31	•	•		•		
	E556-13	E/S0	13.7			•			
	E556-14	S0	14.49						Bar?
	E436-18	S0	15.12	•			•		Small galaxies
									superimposed
	E566-08	E/S0	15.56		•				Spiral?
	E365-29	E	14.79		•		•	•	
	E123-11	E	13.74		•				Spiral-like
									or jet-like
AM1325-292	E444-45	E	13.29		•		•	•	Tidal Origin
AM2319-234		E	–	•				•	Tidal Origin?
	E605-05	–	14.36		•		•	•	Multiple object
AM0012-235		E	≈17					•	Comp.
									pseudo-spiral
AM1945-541	E185-21	E	–	•?				•?	
AM1840-622	E140-44	E	12.69		•				Uncertain
	E545-40	E/S0	13.83		•				
AM2016-330	E400-07	E	15.03		•?				Contamination
									by a star
AM0051-473	E195-11	E	15.27		•		•		Triplet
AM2225-250	E533-31	E	12.96		•		•		
AM2233-613	E147-03	E	15.27					•	
AM0054-634	E079-131	E/S0	15.05		•			•	*Triplet*

Note: Morphological types are determined from inspection of the CCD frame. Columns are: (1) Ripples, Shells, (2) Tail-Plumes, Jets, (3) X-Structure, (4) Dust, (5) Asymmetries

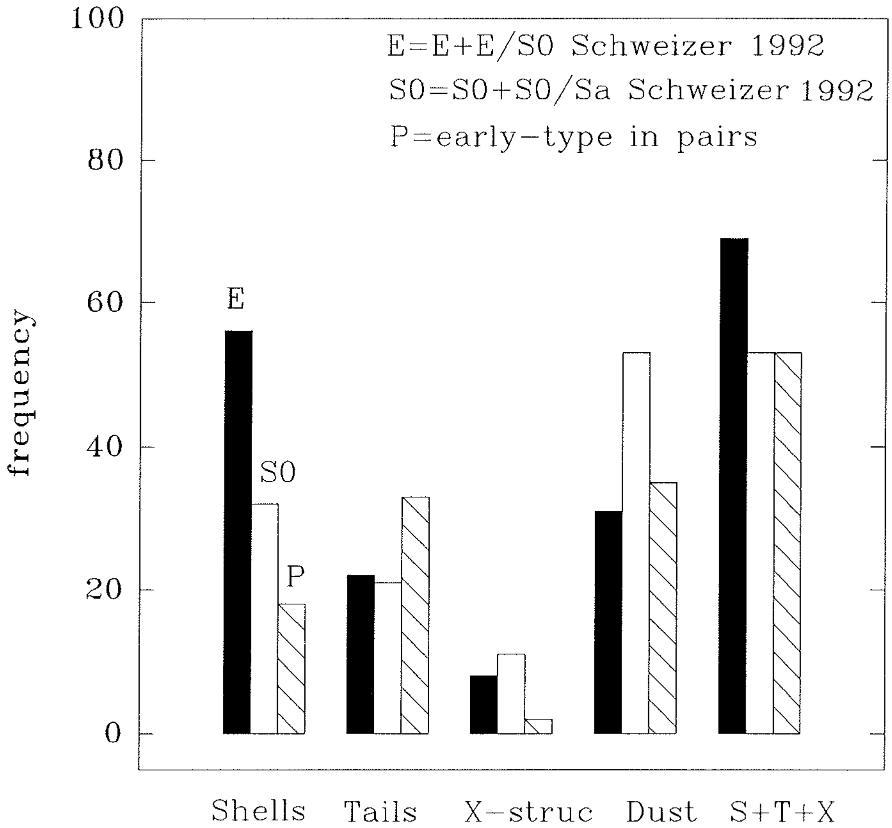


Figure 3: *Detection frequencies for various kinds of fine structure detected in the early-type components of binary galaxies. Results for the Schweizer (1992) sample are presented for comparison.*

domain. This is not intended to suggest that Fourier analysis of galaxy structure is a waste of time. It is just not the easiest approach for the tasks described here.

A median filter is the first tool that one considers when attempting spatial frequency filtering in real space (see Sulentic et al. 1985). One simply chooses a median kernel at least two times larger than the largest feature one wants to preserve. One creates a low pass model with this filter (which "sees" only the extended structure). Subtraction of the low pass model from the original image yields an image with the residual high frequency structure. This approach is infinitely preferable to a mean or gaussian filter in the presence of data with a large dynamic range. For instance, a suitably chosen median filter will not even "see" stellar features in the image while other filters will smear them out. However, even the median filter is not very good in the presence of complex structure such as we are finding in the central regions of galaxies. In the case of ellipticals we can now make use of the generally smooth and axisymmetric stellar distribution and use a modelling approach. This technique has been widely used for enhancing shell structure and for detecting internal dustlanes (see for instance Prieur 1989, Capaccioli et al. 1988, Forbes & Thomson 1992). It usually produces results that are superior to those obtained from filtering.

We used the IRAF reduction package at both Brera Observatory and the University of Alabama to carry out our analysis. Our modelling procedure is based on a method developed by Jedrzejewski (1987) and implemented in STSDAS. After the subtraction of foreground stars by means of squared masks (formed of pixels not considered by the computing algorithm), each isophote of the galaxy under study is fitted by a mean ellipse and parametrized using values of position angle, ellipticity and coordinates of the centre. The deviation from a pure ellipse expressed in terms of a Fourier series is also given. The fourth cosine term in the Fourier series expansion is a particularly useful measure of the deviation from ellipticity, measuring the degree of diskiness or boxiness of the isophotes. The entire galaxy is parameterized in luminosity and geometrical parameters between a minimum (usually 1.5 pixels) and maximum radius. The latter is big enough to include the complete visual extension of the main body of the object. The programme usually starts with some default radius (typically 10 pixels) and increases with a geometrical progression as far out as possible. It then restarts from the initial point and goes down to the centre of the galaxy. We adopted a variation step in the radius equal to 10 %. Each parameter is allowed to vary during the fitting, permitting us to map any small variations and to build up a reliable synthetic model of the object. This model is produced using a bilinear interpolation of the fitted isophotes.

The luminosity of the internal structures is in many cases very low, at most a few per cent compared to the intensity of the galaxy's main body. Still it is possible for the resultant synthetic image to be influenced by their presence. Actually it is known that the fine structures can significantly modify the model isophotes (see Forbes & Thomson, 1992). The subtraction of such a *false* model from the original image may then erase the faint details that we are searching for. In order to avoid this problem we tried to optimize our internal feature enhancement by including luminosity clipping in the modelling procedure. In this way the fitting algorithm can be modified and a percentage up to 40 % of the brightest pixels can be removed from the elliptical annulus to be fitted. This permits us to exclude from the list of examined pixels the ones eventually associated with the superimposed faint details.

Figure 1 shows an example of an image where no hidden structure was found in the residuals after model subtraction. The result was complete removal of the early-type galaxy from the image. This shows that the technique, when correctly applied, does not produce serious artifact. On the other side, Figure 2 shows an example where features are immediately visible. In this case the applied technique can be tested in order to verify that it preserves and enhances this structure. This example shows shell structure which is fairly frequently found in the outskirts of galaxies. Shell features have been interpreted as interaction generated phenomena both with and without an actual merger. In Figure 2 we show one of the pairs studied by Rampazzo and Sulentic. The three panels show: (1) the raw image, (2) enhancement by model subtraction and (3) enhancement by subtraction of a 69×69 pixel low pass median filtred image from the original. The latter frame has been smoothed with a 5×5 boxfilter. Both methods produce a useful enhancement in this case. The model approach further tests if structure exists in the central region by removing the entire starlight component.

Next we focus on possible features near the centres of our target galaxies. The limited number of data points in the ellipse fitting can create a spurious model near the centre. We must be alert

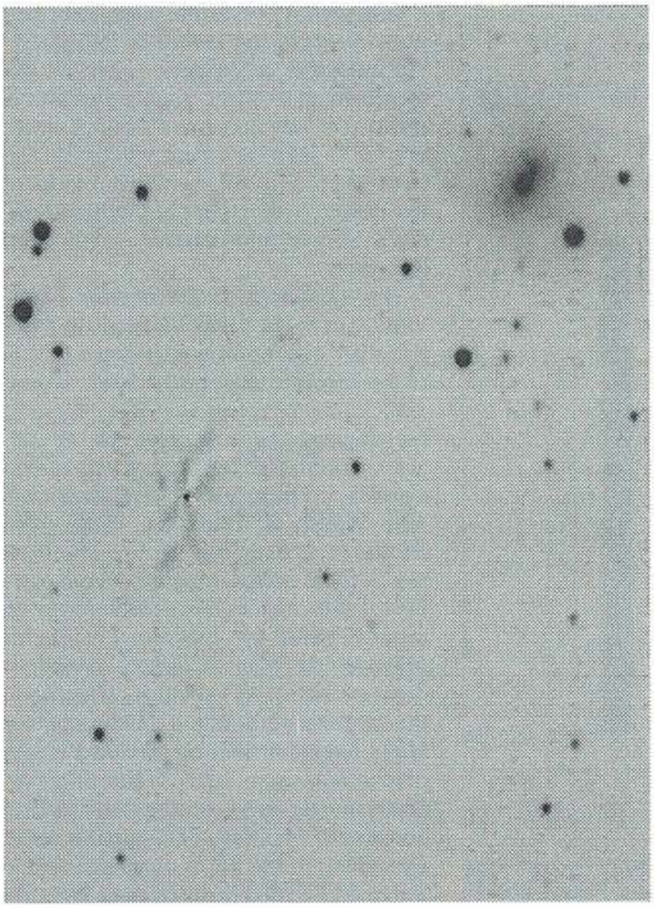


Figure 4: *An example of X-structure found at the centre of E556-13, the early-type component of a non-hierarchical mixed pair. Note the two typical brightness enhancements at the opposite ends of the X-structure also visible in IC 4767.*

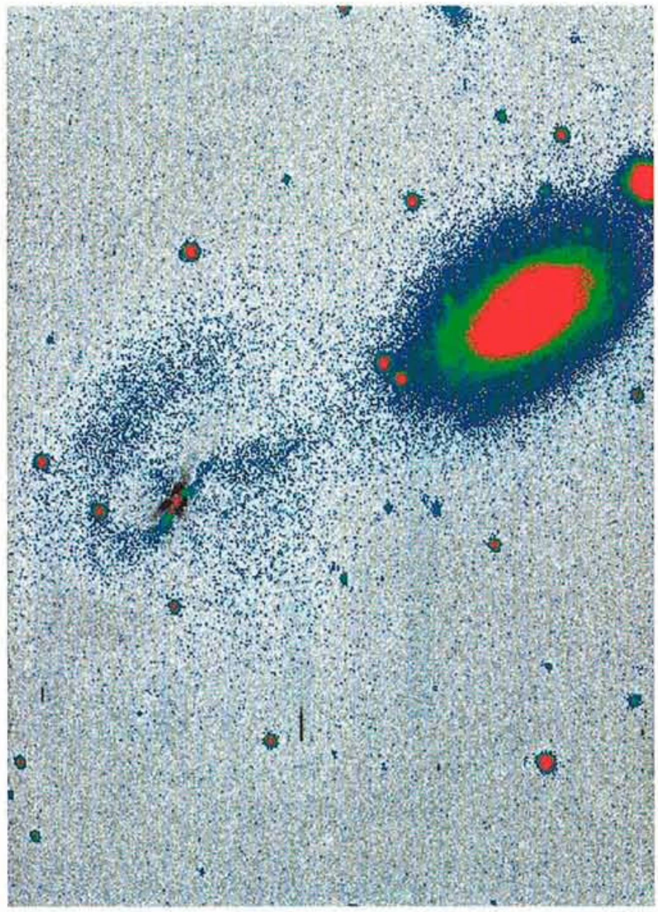


Figure 5: *Fine structure in E123-11. The structure is reminiscent of incipient spiral arms. It appears very sharp at the centre and then widens and becomes more diffuse towards the outskirts.*

to the possibility of false structure related to artifact produced by the model subtraction. The average apparent magnitude of the detected objects was $B_T = 14.5$. Table 1 and Figure 3 summarize the results of our structural analysis. X-structure is one of the less frequently observed forms of fine structure. IC 4767 is the prototype of this structural class (Whitmore & Bell 1988). Figure 4 shows the clear presence of X-structure in the centre of the early type galaxy E556-13. It is the only example in our sample. X-structure has been attributed to a phase mixed population of stars (Binney & Petrou 1985) and can apparently also be created by internal phenomena (see Merrit & Hernquist 1991). Related to X-structure we notice an isophotal boxy structure.

Figure 5 shows an example of an early-type galaxy with incipient spiral or jet-like structure. This is visible in all the photometric bands we studied. Most of the "tail" features appear more indicative of ongoing tidal interaction than as remnants of a past merger event (as in NGC 7252). Two cases, E605-05 and E113-42, show tails more suggestive of a merger in progress (they are imaged in Rampazzo & Sulentic 1992). We observed both of these "E+S" examples because the tail features suggested the presence of a spiral member on the ESO sky survey. E605-05, in particular, appears to be a triplet or compact group in the process of coalescence.

Considering all fine structure (shells, tails, jets, X-structure, dust lanes and patches) we find a detection percentage (see Fig. 3) that is similar to the one found for a sample of isolated galaxies (Schweizer 1992). Our result must be considered preliminary until we have controlled it with a well matched isolated sample. Our sample is fainter on average than the isolated sample we are comparing ourselves with, so we cannot rule out the possibility that we have missed fine structure in some of the fainter galaxies. Our results suggest that early-type galaxies in pairs show no more fine structure than field objects. We think that our percentage is an upper limit considering the subjectivity existing in the classification/identification of various and faint features. It should also be taken into account that the percentage is clearly augmented by tail features that are a direct result of tidal effects rather than merger/accretion events. If we consider features like shells/ripples ($\approx$ 20 %) or X-structure (2 %), we actually find a deficit compared to the Schweizer sample, on average, *by a factor of three*.

We believe that correction for the effect of our fainter sample is unlikely to reverse this deficit. This is all the more surprising because the frequency of other features agrees very well with independent samples and environments. For instance, we find evidence for internal dust lanes in 37 % of our sample which is consistent both with Schweizer (1992) and Ebneter et al. (1988). We would like to make a few preliminary inferences. If shells/ripples are created by interaction with a companion as suggested by Thomson & Wright (1990), we would expect to find an increase of such features in an interacting sample. Since we do not, we are forced to reject this hypothesis. One way out would be to argue that interaction would destroy fine structure after a relatively short period of time. The same argument is valid also in the case of X-structure, the lack of an interaction related excess may indicate that such features are due to internal processes.

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Contribution of the ESO Adaptive Optics Programme to Astronomy: a First Review

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Since 1988, the *Messenger* has kept its readers informed [1] of the steady progress being made in the ESO adaptive optics (AO) programme. The latest developments have been described in detail [2]. We simply recall here the main features. ComeOnPlus [3] is an adaptive system installed at the f/8.09 Cassegrain focus of the 3.6-m telescope at La Silla. It differs from the early prototype ComeOn in many ways: the deformable mirror has 52 actuators (instead of 19); a broader temporal bandpass (30 Hz) is available; modal control, which optimizes the efficiency of AO for a given observation, is implemented, and a user-friendly interface (ADONIS) using artificial intelligence to optimize the use of the system in real time is in preparation. The mechanical structure has been redesigned for high rigidity, and the optical train allows the installation of new elements, possibly provided by visitors, such as a coronograph, single-mode optical fiber pick-up, and in the future, spectroscopic capability or polarimetry.

In parallel, an agreement has been concluded between the Max-Planck-Institut für Extraterrestrische Physik in Garching and the Observatoire de Paris to install and operate a copy of the Sharp Infrared camera used at the NTT. This new camera, called Sharp II, is now on loan to ESO for Periods 52 and 53. ESO is planning to buy an upgraded version of the camera, with some new features, namely a Fabry-Perot spectrometer (resolution ca. 3,000), additional image scales and filters. This upgraded version will then permanently enhance the AO system.

Originally designed as a prototype system to evaluate the value of AO for the VLT, the first version of Come On was soon being used to obtain astronomical data, but was far from being user-friendly. Nevertheless the remarkable results obtained during technical runs in 1992 and 1993 and the unique availability of such a dedicated system on a large telescope encouraged ESO to take the risk of offering this "non-ESO standard" instrument to a broad community. To do so, a new staff member (M. Faucherre) was recruited and trained at La Silla to maintain, improve and operate the system, allowing visiting astronomers to use this new facility without special competence in exploiting adaptive optics. For the past eight months the ComeOnPlus/Sharp II configuration has been offered to visitors (see announcements for Periods 52 and 53), and the requests for observing time have steadily grown in number.

As a consequence, observing programmes of great diversity have benefited from 40 observing nights in Periods 51 and 52, broadly covering the fields of planetary, galactic, stellar and extragalactic astronomy. They all aim to exploit the near diffraction limited and high sensitivity imaging capability of AO, sometimes coupled to other functions such as coronography or spectrography. We present here some recent results in advance of forthcoming publications. They provide a good overview of the variety of fields currently covered by the astronomers using the AO system and demonstrate the worldwide leadership obtained in Europe, as no other group to date is able to present such applications of adaptive optics to frontier astronomical problems.

Solar System

The minor planets Ceres [4] and Pallas [5] were observed successfully. The axis of rotation of Ceres was determined, as well as the value of the ground thermal properties. Titan [5] was imaged in the 1.19–2.14 μm band (Fig. 1), a wavelength where the stratospheric haze is transparent and the low altitude clouds or even the ground may be observed. The ultimate purpose is to characterize the nature of Titan's ground and to test the current hypothesis of a global ocean. The tentative image obtained during Period 51 needs confirmation, and these infrared studies will complement Hubble Telescope observations in order to prepare for the Huyghens descent probe of the Cassini mission, planned to reach Titan in 2004. Examined in this band, Titan exhibits bright areas departing from circular symmetry. These may be caused by al-

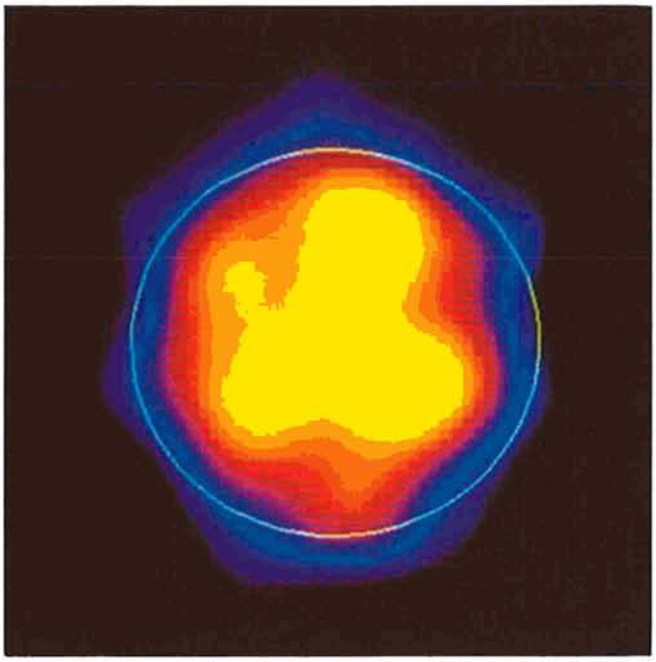


Figure 1: *Titan, satellite of Saturn, observed in the 1.96–2.14 μm band with adaptive optics/Sharp II. The PSF was determined on a star a few minutes before the observation and is 0.18″ wide.*

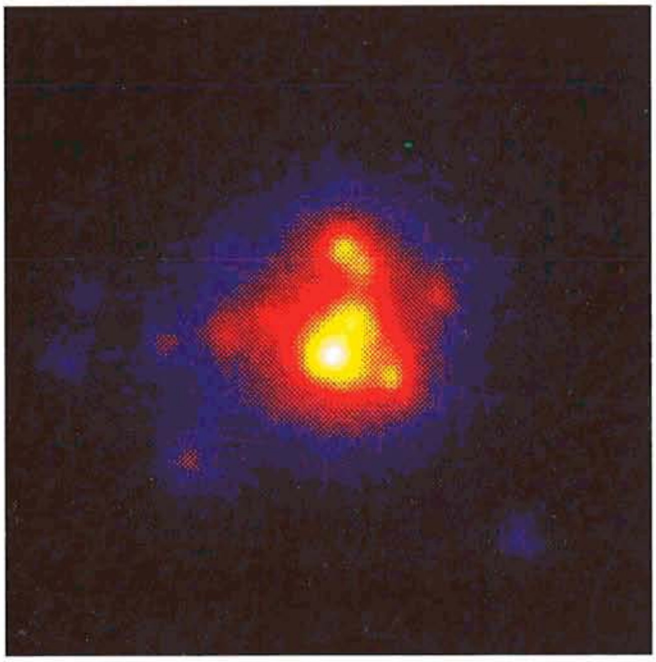


Figure 2: *An image of the multiple star Sanduleak −66°41 in the LMC, obtained in November 1993 with adaptive optics/Sharp II at 2.2 μm. The field is 6×6″, north is up, east left. The PSF is 0.30″ wide, as determined independently. This is a raw image, not yet upgraded by restoration methods. The picture shows mainly the brightest component in the previously resolved cluster. It is now resolved into several previously unknown components.*

bedo variations at the surface or by the low atmospheric cloud structure.

Stellar Astronomy

The detailed structure of massive stars was first examined with optical speckle interferometry, aiming to resolve assumed supermassive objects into multiple systems. One of the very massive stars, Sanduleak−66°41 in the Large Magellanic Cloud, was believed before 1988 to be over 120 times more massive than the Sun. However, observations conducted in 1988 [6] with the ESO 2.2-m resolved the assumed star into a tight cluster of six objects, and the mass of the most massive object was lowered to 90 $M_\odot$ [7]. Figure 2 shows how the AO observations, carried out in November 1993, again modify this result. The previous 90 $M_\odot$ object has been resolved again and the brightest component will again decrease in mass. Establishing the upper limit of massive stars is fundamental for theories of birth and evolution of stars, as well as for the determination of the cosmic scale.

Circumstellar Environment

The high resolution AO imaging of young stars has already led to the discovery of the disk surrounding the close binary ZCMa [8].

The evidence for a circumstellar disk and associated bipolar flow in the active object η Carinae [9] (Fig. 3) has been an object of interest. η Carinae was observed early in the AO programme (April 1991) and demonstrated the mapping capability of relatively extended objects (6×6″) when the central source is bright. New observations are planned in 1994 to determine with accuracy the relative position of the infrared core with regard to the multiple object discovered earlier in the visible by Weigelt with speckle interferometry. The infrared detailed core map confirms the bipolar structure observed at larger scale (30″) by the

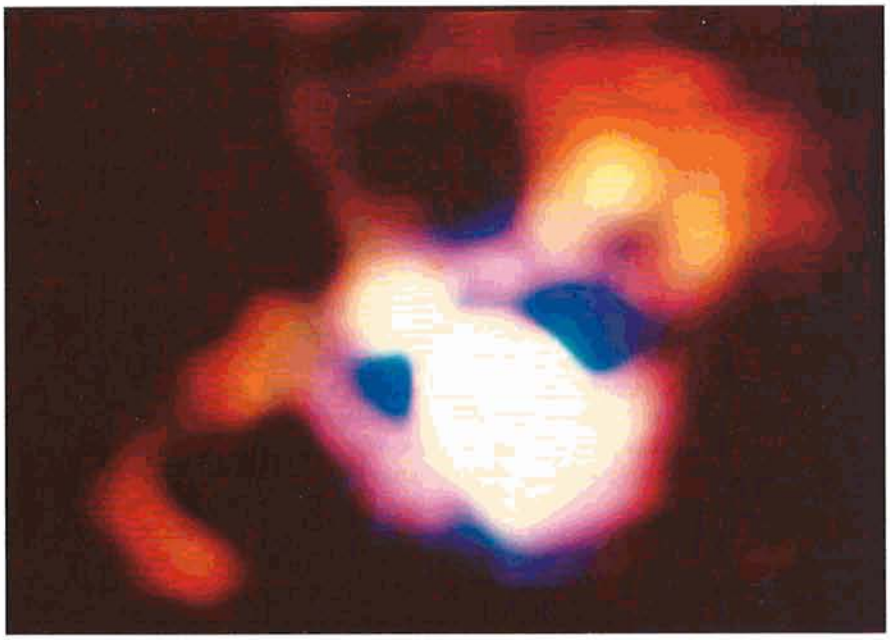
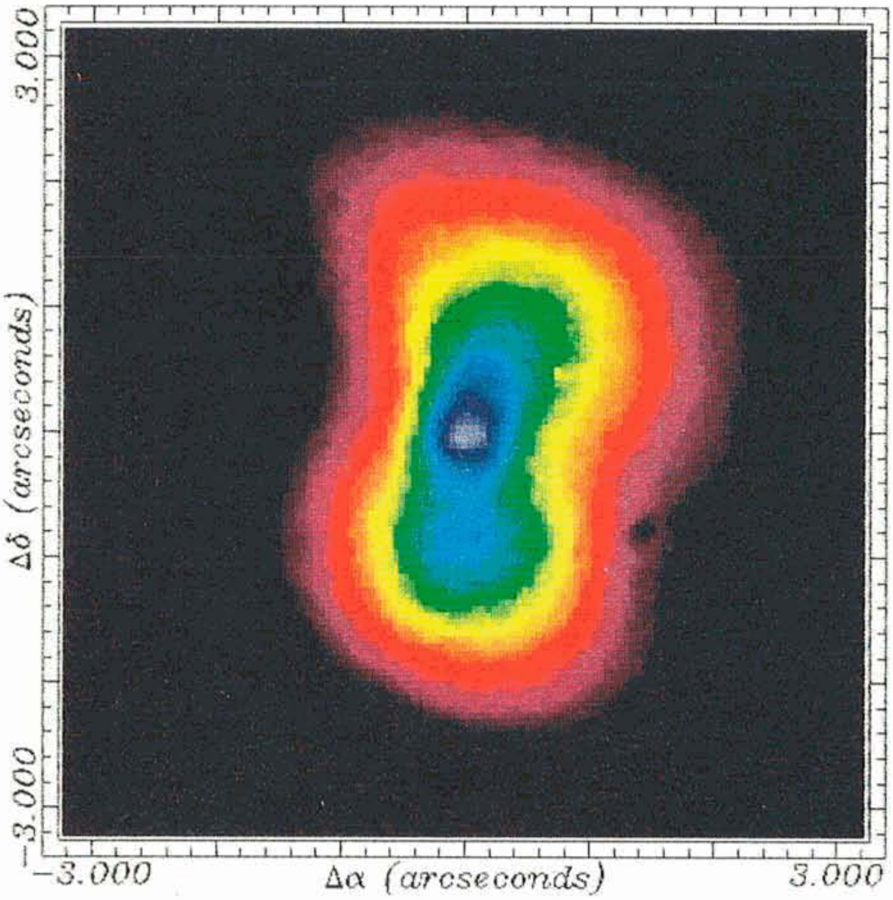


Figure 3: *The centre of the η Carinae nebula observed in January 1991 with adaptive optics/ Circus camera. The image size is 4×5″, east is up and north to the right. The colour map is a composite of L′(3.6 μm) and M (5 μm) bands where colours represent colour temperature (blue is hot, red is colder). The dust temperature is determined with a resolution of 0.26″ to be 300–350 K, decreasing away from the central heating source. The positioning accuracy of L′ and M maps is 30 milliarcsec, after correction for instrumental flexure.*

Figure 4: *The Frosty Leo nebula (post AGB star) observed in the K′ infrared band with adaptive optics/Sharp II. The field is 6×6″, north is up and east is left. The PSF was determined to be 0.3″ wide, despite 1.5″ seeing due to relatively poor observing conditions. The nebula main axis is tilted by −14° with regard to the north-south direction. The narrowing of the isophotes near the equatorial plane is an indication of the disk embedding the central object. The nebula is asymmetric and the suspected presence of an unseen companion, the obvious central object, is on an orbit 0.25″ away from the exact centre. Exposure time 300s.*



HST and gives hints on sporadic ejection of matter which may be related to the ultrabright event of 1843.

An object of particular interest is the evolved post Asymptotic Giant Branch bipolar source Frosty Leo (Fig. 4), where evidence for a disk seen edge-on was previously complemented by the demonstration of the dust-to-gas relative velocity. Adaptive optics imaging of this source in April 1993 allows us to identify and precisely locate the central star [10]. Its excentric position, relative to the accurately positioned nebula isophotes, strongly suggests that a binary system is at the origin of the disk and bipolar structure. In addition, knowing from previous measurements the propagation velocity of the ejected shell (10 km/s), it is possible to derive the position of the emitting object from the isophote centroid position. It is remarkable that the positions of these centroids regularly move and give hints on what could be the orbit of the emitter. This orbit fits with the current position of the observed star and a companion mass (ca. 6 $M_\odot$) may then be derived.

Many current programmes deal with bipolar flows and jets, circumstellar disks around young or evolved stars, etc., where the superior resolution of AO becomes extremely valuable.

Star Clusters

The possibility to resolve rich fields of stars with 0.1″ resolution has two advantages: by reducing the background and concentrating the energy, it increases the sensitivity and by sharpening the image it reduces confusion.

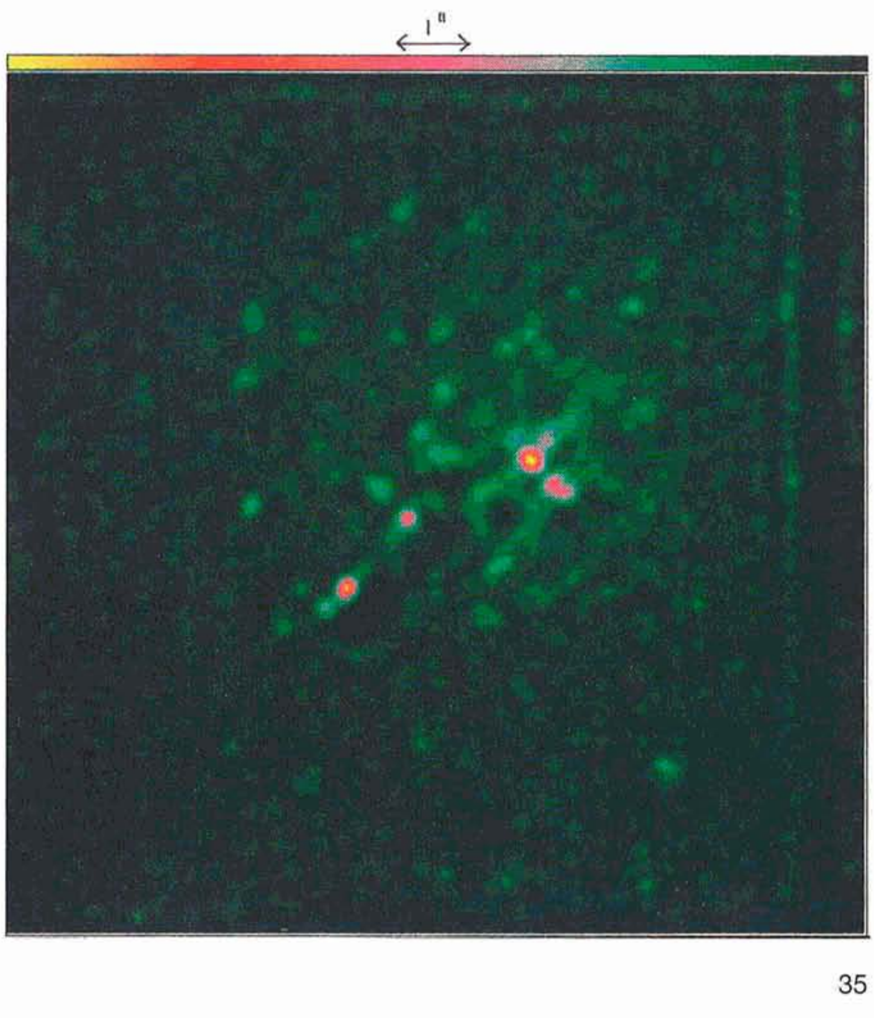


Figure 5: *The R136 region in the Large Magellanic Cloud 30 Doradus nebula, imaged at 2.2 μm by adaptive optics/Sharp II. The resolution is 0.2″ FWHM, north is up and east left. The scale is indicated. Fainter stars in the cluster may be either OB stars or perhaps red supergiants.*

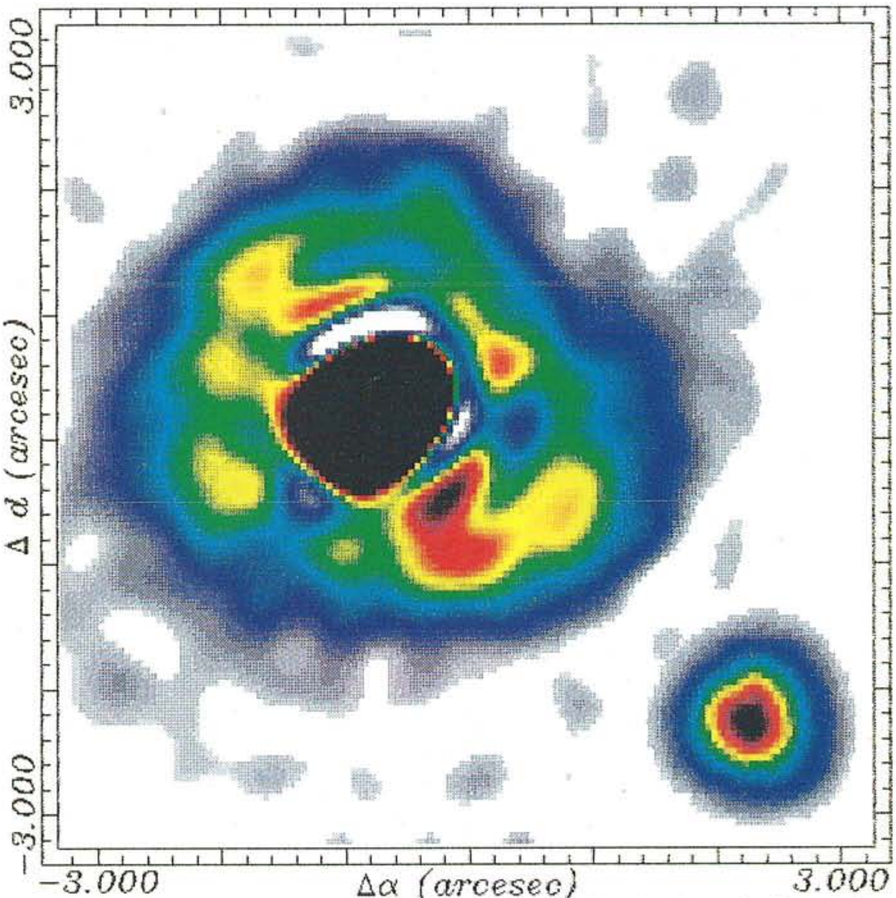


Figure 6: *The Seyfert I galaxy NGC 7469, imaged at 2.2 μm with adaptive optics/Sharp II. The image is 6.4×6.4″ and the estimated resolution is 0.6″ before detailed deconvolution and cleaning treatment. The nucleus is saturated and isophotes were removed. North is up and east left, exposure time 20 seconds. The PSF is at the lower right. See also page 20 of this issue.*

more than thirty massive Wolf-Rayet, O and B stars and is known to be a location of recent massive star formation.

Star Forming Galaxy: NGC 7469

The SAb galaxy NGC 7469 is a Seyfert I galaxy presenting an active nucleus surrounded by a starburst region. The star formation triggering process is not known and several hypotheses have been formulated: tidal effects from a companion, bar, etc. AO observations carried out in July 1993 demonstrated the existence of a structured ring (Fig. 6) which was mapped in J, H and K bands despite bad observing conditions. The preliminary data analysis [12] indicates that the main emission comes from red supergiants (M0-M5) and that fairly high starburst activity ($L_* = 10^{11}\ L_\odot$) is consistent with the luminosity measured by others. This observation provides a good example of AO capabilities on relatively faint objects, as the magnitude of the nucleus, used for referencing, is 12.

The galaxy NGC 1068 is also currently being studied and results should soon become available.

High-z Galaxies

This programme searches for primeval galaxies. As they are not sufficiently bright to provide adequate referencing, a completely different strategy is used:

Hence systematic studies of stellar populations become possible in the near infrared. One application is to determine the low mass, faint star distribution in star forming regions at an early stage, as proposed among others by S. Strom and C. Dougados. The comparision with Hubble Space Telescope images taken in the visible at a similar angular resolution will be extremely instructive in determining with accuracy the colours of individual objects.

We illustrate here (Fig. 5) the first result of a programme aimed at constraining the Initial Mass Function by observing with AO the rich active region R136 in the 30 Doradus nebula in the Large Magellanic Cloud [11]. It contains

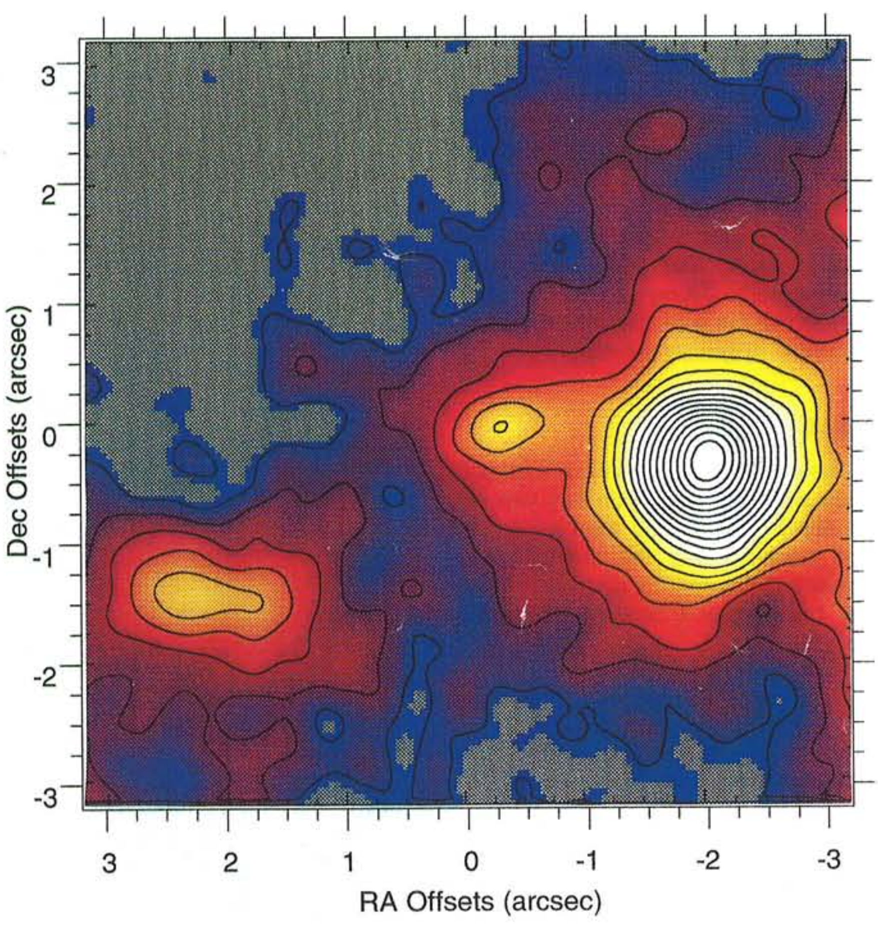


Figure 7: *Image of a rich field of galaxies at z = 0.42 at 2.2 μm, given by adaptive optics/Sharp II. Resolution is 0.4″. The two known galaxies in the cluster J1836.3CR are clearly spatially resolved and a third source (centre of image) unknown till now is detected. Contours are 5, 10, 15...100 % of $m_K = 15.2$ arcsec^{-2}. The reference star ($m_V = 13$) is 25″ away and isoplanicity limits the resolution. The 5σ limit for 1 hour integration is $m_K = 21.1$.*

stars adequate for referencing are selected in fields which are expected, from a variety of criteria, to be rich in remote galaxies. These fields are systematically mapped as far from the star as possible, given the size of the isoplanatic field (usually 20–30″, depending on the seeing, the amount of expected correction and the wavelength of operation).

In the beginning phase of this programme two galaxies were observed in K in the cluster J1836.3CR at a redshift z = 0.42 [13]. The spatial resolution is 0.4″ and the galaxies are clearly resolved (Fig. 7). Their integrated magnitudes are K = 15 and K = 18. The V-K colours indicate the brighter source to be an elliptical and the fainter a spiral galaxy, as confirmed by the examination of the clearly visible shape of the images. This programme will be pursued in a systematic way in order to determine the colours and morphological types of remote galaxies.

The ESO Adaptive Optics system was initially conceived as a technological prototype. Its performance now makes it a valuable tool whose uses will continue to grow and fully exploit the excellent seeing of the 3.6-metre after the recent improvement of the dome thermal control. It is hoped that this continuous operation and scientific productivity shall ease the design and operation of the AO system(s) on the VLT for a broad community of astronomers, especially as regards the ground follow-up of the Hubble Space Telescope and of the ISO satellite mission to be carried out between 1995 and 1997.

Many other aspects of adaptive optics need to be covered in the future, if possible before the VLT system(s) are put into operation: infrared wavefront sensing (possibly reaching magnitudes $m_K = 8-10$), improved wavefront sensing at visible wavelengths using ultra low noise, fast readout CCDs (reaching $m_V = 17-18$ for low-order AO correction), understanding the detailed properties of turbulence and its associated optimized correction [14]. And this is without speaking of laser artificial stars, which could easily be tested and put into operation, after proper study of stray light effects, on the powerful ComeOn Plus/Adonis system.

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The New Data Management Division at ESO

P. BENVENUTI, ST-ECF

At its last meeting in December, the ESO Council approved the proposal by the Director General for the constitution of a new Data Management Division. The purpose and scope of this new division are not totally new to ESO: it will have under its responsibility the support of those activities which produce, process, store and distribute scientific data and information, all tasks which are already carried out by different groups in ESO. The rationale for the reorganization of these activities within a division is based on the recognition of their growing importance in the operation of an observatory and on the consequent need for a better coordination among them and for a more rigorous link between them and the requirements of the users of complex modern telescopes, in the case of ESO of the refurbished NTT and of the VLT.

It is becoming evident, particularly from the experience of operating space observatories, that the various tasks and services which an observatory has to perform and offer in support of its users community, cannot anymore be considered in isolation, rather they must be seen in the context of an end-to-end model of operation. According to this model, which is schematically shown below, the information and the science data should flow transparently from the preparation of an observing proposal, through the observation, calibration and reduction up to the storage of the data into the archive.

The user should be able to access this information at any time, possibly remotely via computer: for example, when retrieving a set of public data from the archive, she or he should be able to access at the same time the abstract of the proposal to which the data belong, as well as the performance of the instrument at the time of the observation, the relevant calibration data and procedures and any other related information which can be useful for a scientific exploitation of the archive. Similarly, a user who intends to submit an observing proposal should be able to obtain up-to-date information about all the ESO telescopes and instruments and possibly perform realistic simulations of her/his observations, or retrieve similar relevant data from the archive. These latter requirements will become essential if, as it is planned for the refurbished NTT and for the VLT, part of the observations will have to be performed in service mode. In this case the observatory should also have available tools for real-time scheduling of observations according to their priority and to the prevailing meteo and seeing conditions, even if they belong to different proposals.

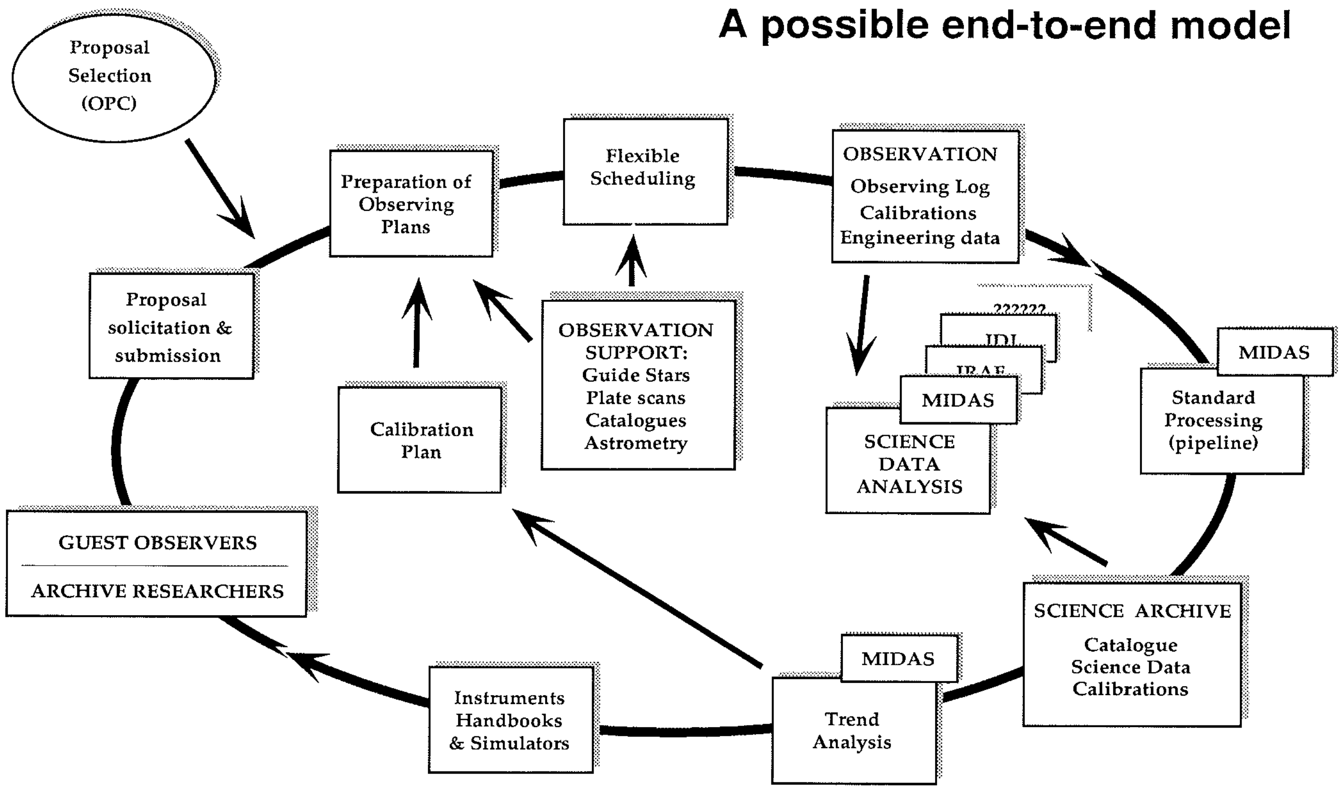
The new Data Management Division will have to provide the support for the implementation of this end-to-end scheme of operation, with the noticeable exception of the data acquisition processes and telescope control which is the task of a specific group in the VLT Division and with which the Data Management Division has an important interface.

The high-level requirements which will be used as a guide for planning the Division activity can be summarized as follows:

- Users shall have access to complete and up-to-date information on all ESO facilities. This information shall be offered using state-of-the-art technology and, if network capacity permits, shall be accessible remotely.
- There shall exist software simulators for the major ESO observing facilities.
- Tools for remote proposal entry shall exist. These tools shall be designed to include sercive observing mode.
- A flexible scheduling system, which is capable of quasi real-time rescheduling, shall exist.
- Quick-look tools shall be available to the users of the telescope and of the archive for real-time evaluation of the scientific quality of the observations. The user shall be able to compare, in real time, her/his observations with simulations and with existing data extracted from the archive.
- Reduction and calibration procedures and their software implementation shall exist for each observing mode of the ESO facilities. ESO shall define the standards for the development and implementation of this software and coordinate and monitor its development when this is done by third parties.
- Calibration plans and calibration databases shall exist for each observing mode.
- ESO shall maintain knowledge and expertise on the state-of-the-art data analysis systems and offer limited support to the users on their utilization in the analysis of astronomical data.
- ESO shall develop advanced methods for the analysis and interpretation of astronomical data.
- All scientific data shall be archived together with the information which is needed for their scientific use.
- Users shall be able to browse through the archive and retrieve public data.
- ESO shall be a European focal point for astronomical applications of advanced software techniques.

It is quite clear that these requirements are very demanding and that their implementation, given the limited manpower currently available, should be carefully planned in a staggered schedule according to priority. At the time of writing, this prioritization analysis has just started and it will be presented in detail in a forthcoming issue of the *Messenger*. We can however indicate here the guidelines along which the main activities of the division will unroll. In order to obtain a better coordination and control, four groups have been formed within the new division: Observation Support and Data Management, Science Data Analysis, Computer Management and Operations, Advanced Systems and Planning.

The long-term goals of the first group, led by Miguel Albrecht, is to implement an environment, based on advanced information handling techniques, which allows a user to efficiently prepare an observing proposal. Within this environment the user, starting from a scientific idea, should be able to consult the literature on the subject, extract the fields containing the objects of interest, identify guide stars and pointing strategies, browse through existing data and observations of the same type of objects, identify the ESO instrument which is best suited for the specific science, experiment with the instrument simulator in order to optimize the exposure time and the observing procedures, fill and submit the observing proposal. Currently, the highest priority is given, in close collaboration with the NTT Group, to the definition and implementation of a calibration plan for the EMMI and SUSI instruments and of the procedures for monitoring their performance. Another



important activity of the group is the redefinition of the tools for the submission and handling of observing proposals, following the requirements of the NTT refurbishment plan and of the new Observing Programmes Committee.

The Science Data Analysis Group is led by Preben Grosbøl, who is also the Deputy Head of the Division, and it is essentially the previous Image Processing Group which has a long and successful tradition in the development of Data Analysis Systems. One of its tasks will continue to be the maintenance of the MIDAS system. However, its activity is now focussed on the definition and implementation of reduction and calibration procedures for all ESO instruments, both for those in operation and those under development for the VLT. Similarly, in collaboration with the VLT Software Group and the Operation Group at La Silla, the tools and procedures for a quick-look analysis of the observations will have to be defined and implemented for each instrument.

The tasks of the Computer Management and Operations Group, led by Peter Dierckx, are rather obvious and certainly not new. The change is rather in scope, since the group will take under its responsibility the management of all the different local area networks in ESO with the exclusion of that used by the Administration. A number of rationalizations and standardizations are planned which should result in an overall improvement of the service.

The last group, Advanced Systems and Planning, is led by Joseph Schwarz and has the broad (and ambitious!) task of keeping ESO on the forefront of computers and software evolution. It should monitor the development of systems in different areas and propose their application to specific ESO activities. The first output of this group, the manpower of which is drawn from all groups in the division and also elsewhere in ESO, will be a medium long term plan for the evolution of hardware and software at ESO.

The main problem which is affecting all groups is the severe shortage of manpower when compared with the tasks which should be fulfilled: as mentioned before, we will try to cope with this difficulty by proper prioritization and rationalization of our activities. In particular we could foresee a more effective integration of similar ESO and ST-ECF tasks, following the successful example of the development and operation of the archive. Also, several astronomical projects are currently tackling problems which are similar, if not equal, to those faced by ESO for the operation of NTT and VLT: whenever possible we will try to establish effective collaborations which, as it was shown in the case of the archive joint development with the ST Science Institute and with the Canadian Astronomical Data Centre, can save resources and avoid unnecessary duplication of effort.

The ESO Library Information System

U. MICHOLD, ESO Library Garching

Since November 1993, the automated ESO Library Information System is available to the public. At present, it provides access to three components: The *Library Catalogue* can be searched, the so-called *Information Desk* offers lists of new acquisitions, and users can enquire about their *User Status*, i.e. view the items they have on loan.

Two user guides are available: The brief *ESO Libraries Online Catalogue in a Nutshell* and the more detailed *ESO User Guide to the Online Catalogue.*

Following is a short introduction to the system. If you are interested in further information or would like to obtain the user guides, please contact the librarians at the Main Library in Garching (esolib@eso.org on the Internet).

1. How to Access the ESO Library Information System

The Library Information System is installed on ESO's libhost computer. From within ESO, you can reach the machine by using one of two different logins:

- rlogin -l library libhost (defaults refer to Main Library, therefore it is the recommended login for users in Garching) or
- rlogin -l lslib libhost (defaults refer to La Silla Library, recommended for users in Chile).

X-terminal users from within ESO will find it convenient to bring up a window with the library system by simply pressing the left mouse button and choosing the LIBRARY option from the root menu (defaults will refer to Main Library).

From outside ESO, you can telnet into the system:

- telnet libhost.hq.eso.org
  login: library or login: lslib

Once you are connected, please specify the terminal type you are using by selecting from the list presented. Users of PCs probably will have to choose the vt100 terminal type.

2. The Library Catalogue

2.1 Which Library items can be found in the Catalogue?

The ESO Libraries Online Catalogue contains all Books, Journals, Standards, CD-ROMs, Diskettes, Microfiches, Video-Tapes, Slides, and Observatory Publications available in the ESO Libraries in Garching (Main), La Silla, and La Serena.

The database includes journal titles and the holdings of these journals that you will find in each of the three libraries, but does not refer to individual articles.

In addition, the inventory of the ESO Historical Archive (EHA), compiled by Prof. A. Blaauw can be searched. In future, also Preprints received in the ESO Libraries will be retrievable.

2.2. How to query the Catalogue

The software is easy to use and mainly self-explanatory. Every screen is divided into two parts: Above a dotted line, you find commands and options. You can move around in this area by using the TAB key and pressing RETURN or by typing the first letter of the option.

Below the line the information you retrieved is displayed. This might be a list of brief records or a record in full. To move around here, you usually need the arrow keys.

Once you have entered the Library Catalogue, you can specify if you want to query the catalogue by AUTHOR, TITLE, OTHER COMBINATIONS, etc. or just by any WORD OR PHRASE, which is usually the most convenient choice, because it searches the whole database for the search term. This option is also recommended if you want to look up keywords. Use the Boolean Operators AND, OR, NOT, if required (Fig. 1).

```
To pick a new button, first return to buttons by pressing TAB(s).
Type in the words you want to lookup below, then press ENTER, $ truncates
HELP            GOBACK          STARTOVER       PRINT
CLEAR           TYPE            OPTIONS
--------------------------------------------------------------------------------
                                CATALOG LOOKUP BY WORDS OR PHRASE

words or phrase   ====>VLT OR VERY LARGE TELESCOPE

       library   ====>MAIN

PAGE 1                                               (c) Sirsi Corporation 60e
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Figure 1: *Catalogue Lookup by any Word or Phrase.*

```
To pick a new button, press TAB or button's first letter.
To see more about an item, enter its number, then press RETURN or ENTER.
HELP            GOBACK          STARTOVER       PRINT
VIEW:8          JUMP TO:
FORWARD         BACKWARD        MARK:
--------------------------------------------------------------------------------
                      YOU FOUND 16 ITEMS IN THE CATALOG
    8) Telescope and observatory interfaces for      copies: 1 (MANUALS)
       Cullum, M.J.                                      at: MAIN & others
       A 4-2 / 149                                  pubyear: 1990

    9) ESO's Very Large Telescope : 2 : 1986         copies: 1 (T.BEDDING)
       D'Odorico, S.                                     at: MAIN & others
       A 4-2 / 112                                  pubyear: 1986

   10) Very Large Telescopes, their                  copies: 1 (MANUALS)
       Ulrich, M.H.                                      at: MAIN & others
       A 4-2 / 90                                   pubyear: 1984

   11) ESO VLT instrumentation plan                  copies: 1 (SHELVES)
       European Southern Observatory (ESO)               at: MAIN & others
       A 4-2 / 131                                  pubyear: 1989
PAGE 1                                               (c) Sirsi Corporation 60e
```

Figure 2: *List of Search Results.*

```
To pick a new button, press TAB or button's first letter.
To view the next item(s) you found, press RETURN or ENTER now.
HELP            GOBACK          STARTOVER       PRINT
REQUEST:        LIKE            OPTIONS
FORWARD         BACKWARD        MARK
--------------------------------------------------------------------------------
         THIS IS RECORD NUMBER 8  OF THE 16 YOU FOUND IN THE CATALOG
A 4-2 / 149

      ESO class mark: A 4-2 / 149
               Title: Telescope and observatory interfaces for VLT
                      instrumentation
           Publisher: Garching: European Southern Observatory, 1990
Physical description: 64 p.
              Series: ESO Very Large Telescope Project
       Series vol no: Doc.no: TS-T1E3-1 (1)
              Editor: Cullum, M.J.

                         (Displaying 1 of 2 volumes)

    MAIN CALL NUMBER                                COPY MATERIAL   LOCATION
  1) A 4-2 / 149                                       1 BOOK       MANUALS
PAGE 1                                               (c) Sirsi Corporation 60e
```

Figure 3: *Record 8 of 16 retrieved is displayed in full.*

Please note that the dollar-sign ($) must be used to truncate search terms!

On all Catalogue Look up screens, an additional line allows you to specify whether you want to limit your search to items in one particular library (MAIN, LA-SILLA, etc.) or whether you want to query the whole catalogue (Library: ALL).

As a result of your search, usually a list of brief records will be displayed. You will be informed about the exact number of items you retrieved. For each item, the author, title and class mark as well as the publication year and the current location are shown (Fig. 2).

If you want to see more details of one particular record, place the cursor on this record and type VIEW. The full record will be displayed. If it doesn't fit on one screen, press the FORWARD button that takes you to the second page where you will also be informed about the Class Mark (Call Number), the format (Material), how many copies are available and where they can be found (Location). In case an item is on loan, the name of the borrower is displayed (Fig. 3).

If you are not satisfied with your search results, use the GOBACK or the START OVER button and refine your query.

2.3 Marking items

The MARK function is a preparation for printing or mailing search results by e-mail. In order to MARK items, TAB to the MARK button and enter the list number of the item you want to mark. Confirm by pressing RETURN. An asterisk between the list number and the title tells you that the item has been marked. If you want to remove the print mark, just go through exactly the same procedure again or, in case the cursor is still placed on the item you want to unmark, simply press RETURN again.

On every new screen, TAB again to the MARK button and proceed as described. Unicorn will refer to your list of MARKed items if you enter the PRINT command.

2.4 Mailing search results by e-mail

For further usage of your search results, you may want to send the results by e-mail to your own account. You can do so by using the PRINT command button. On the PRINT screen, choose the PRINT SEARCH RESULTS option. If you MARKed particular items on the Lookup screen before, the system will default to the selected records and offer to print them. You can add or delete record numbers or just mail the whole list by typing ALL in this field. TAB to the EMAIL ADDRESS line and insert the address. Confirm by pressing RETURN (Fig. 4).

2.5 Exiting from the Library Catalogue

If you wish to exit from the Library Catalogue, press the STARTOVER button several times, until you reach the PUBLIC ACCESS CHOICES screen. From here, you may move into other areas than the Library Catalogue. e.g. the Information Desk.

If you want to leave the system completely, press STARTOVER again. You

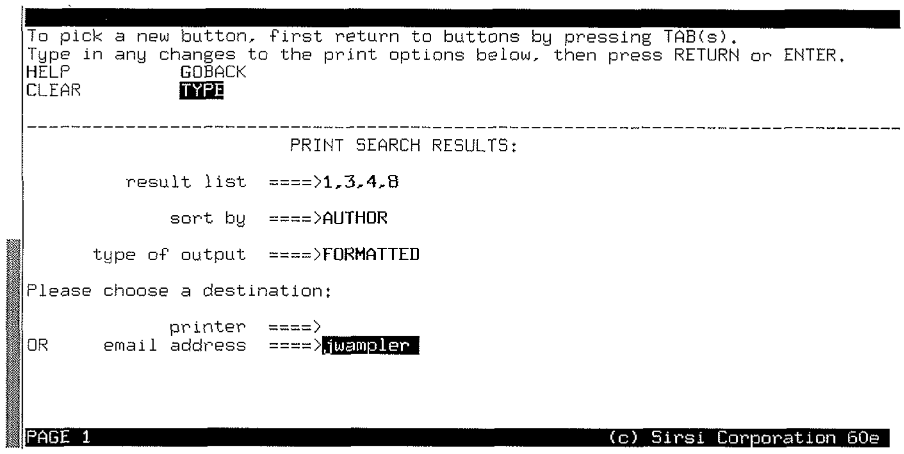


Figure 4: *Mailing Search Results by E-Mail.*

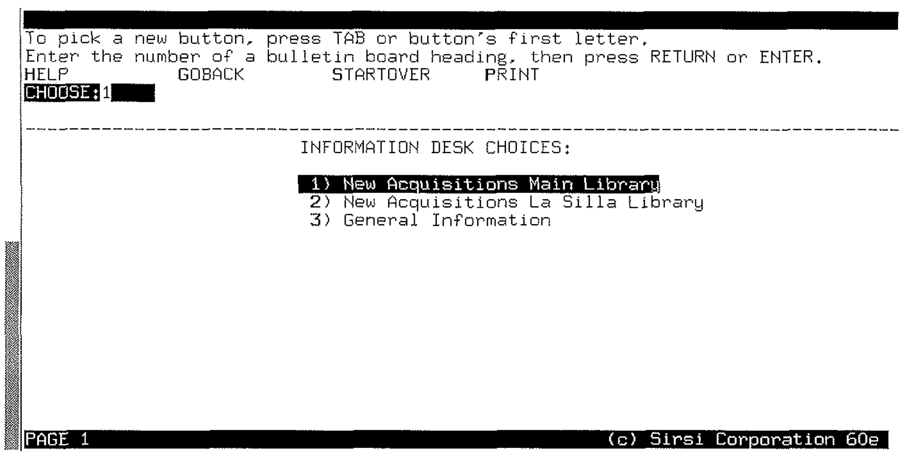


Figure 5: *Options on the Information Desk.*

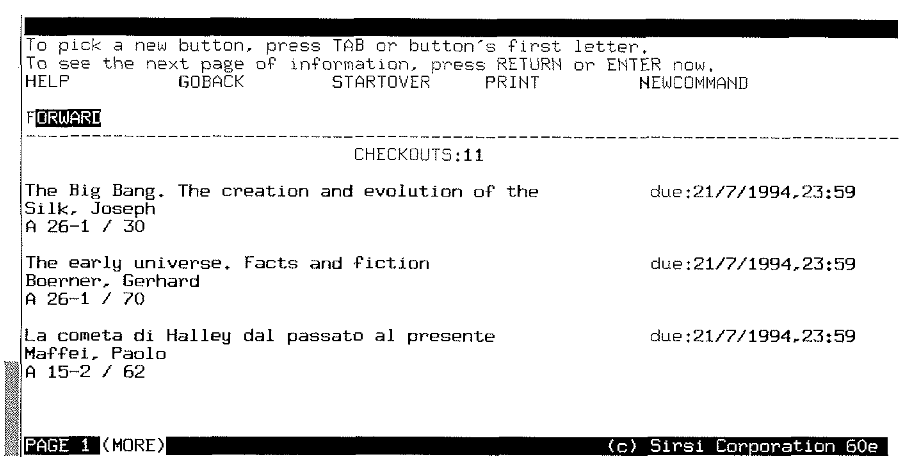


Figure 6: *User viewing his Checkouts.*

will be returned to the Welcoming screen. Choose END, and you exit from the system.

3. Borrowing Items

In order to charge items out, you must have an account with the library. Please contact the librarians if you wish to get one.

Borrowing items is only possible at the public terminals in the libraries. Press the function key which is reserved for CHARGING items, insert your user ID and Personal Identification Number (PIN), and confirm by pressing RETURN.

You will be asked for the number of the item you want to charge out. On the inside cover page of books you will find a barcode label, showing the item number. Use the barcode reader which is attached to the terminal to read the barcode number in.

4. Information Desk

The Information Desk provides access to various lists of catalogue items and library memos. For example, new acquisitions in the ESO Libraries will be announced here for one month. The buttons known already from the Library Catalogue are available here, too. You may browse through the list or view items in full, as you wish (Fig. 5).

5. User Status

Via the option USER STATUS on the Public Access Choices screen, users may view their own circulation status, i.e. how many and which items they have charged out. This option is available from every terminal.

On the User Status screen, the system prompts you to type in your user ID. Use the tabulator key to TAB to the PIN field and insert your Personal Identification Number. Press RETURN to confirm both numbers. For questions regarding User ID and PIN please contact the librarians.

You may select from various options regarding the User Status, of which at present only the CHECKOUTS are of interest to users of the ESO Libraries. The top of the information area shows the total number of items checked out. Below, a list of your currently charged out library items is displayed. If the checkouts don't fit on one screen, the FORWARD button appears and is pre-selected. You also see the note MORE on the bottom line of the screen.

Press the GOBACK button to return to the previous screen. Type STARTOVER or GOBACK again to return to the Welcoming screen (Fig. 6).

6. Exiting from the System

You leave the Library Information System by pressing the STARTOVER button several times until you reach the Welcoming Screen. Press END to leave the system.

7. One Look Ahead

The availability of an online library catalogue is the necessary basis for all further improvements and projects related to bibliographic data management at the ESO Libraries. The library information system can thus easily be integrated into the activities of the recently established Data Management Division.

For the near future, the following enhancements, which will be carried out by the Observation Support and Data Handling Group of the Data Management Division, are planned or considered:

- *Preprint Database*
  At present, preprints received in the ESO Libraries can be found via STARCAT. In order to provide users with an integrated catalogue, a data transfer utility will be set up, and all library items including preprints will be retrievable through the Library Information System.
- *IAU Astronomy Thesaurus*
  The first version of the IAU Astronomy Thesaurus, compiled by R.M. Shobbrook & R.R. Shobbrook, has just been released. The thesaurus is available in machine-readable form. Inclusion of the thesaurus into the Library System will allow users to search for terms within a controlled thesaurus structure, both hierarchical and cross-linked via related terms.
- *Mosaic User Interface*
  The ESO Libraries Online Catalogue could be accessible via the Mosaic user interface in order to facilitate access to the holdings of all ESO Libraries. Such a function would be implemented via a simple search and retrieve interface.
- *Optical Character Recognition (OCR) Interface*
  An OCR station located in the library could provide both general users and librarians with a tool to scan data and text. For example, the Library System could be routinely fed in this way with additional information such as references to single publications within proceedings (contents tables).

8. Acknowledgements

We would like to take this opportunity to thank all staff at ESO who supported the computerization of the Libraries, especially Miguel Albrecht, our "Maestro", who solved so many of our problems, as well as Pam Bristow for proofreading several texts and Ed Janssen for designing the User Guides. We are also very thankful to our contractors in Garching and on La Silla, Uwe Glas, Carolina Noreña, and Lucia Montes; we wouldn't have been so quick without their enthusiasm and energy.

Special thanks go to astronomy librarians all over the world for answering patiently our many questions, especially Ellen Bouton (NRAO, Charlottesville), Brenda Corbin (U.S. Naval Observatory, Washington), Robyn Shobbrook (AAO, Epping), and Sarah Stevens-Rayburn (STScI, Baltimore), who always shared their knowledge and expertise with us, explained their points of view and helped whenever necessary.

We are also very grateful to Barbara Pacut and Nick Dimant from Sirsi Ltd., London, who provided excellent customer support and never lost patience in spite of all our questions concerning the Unicorn Library Management System.

Last, but not least, we would like to thank all users of the ESO Libraries, who accepted many inconveniences during all phases of the computerization without complaint and thus enabled us to spend all our energy on this project.

The New ESO Observing Programmes Committee

J. BREYSACHER, ESO

1. Introduction

As shown in Figure 1, the number of proposals received by ESO per observing semester has considerably increased over the past sixteen years. Today, about 500 proposals per period are currently submitted. This healthy situation, which reflects the dynamism of European astronomy, is also a matter of concern for the ESO Observing Programmes Committee (hereafter OPC).

The appointment of OPC members-at-large – a process which started in 1988 when the number of proposals per period was of the order of 350 – has contributed to keep at an acceptable level the amount of work for each OPC member, but now with 500 proposals or more the situation is becoming critical again.

How to reduce the workload of the OPC while still improving the quality of the refereeing work is a topic which has been extensively and often debated by this Committee. Among the various proposed alternatives to the present system, the appointment of a number of discipline-oriented sub-committees appears to be the most attractive and realistic approach.

2. Structure of the New OPC

2.1 Appointment of sub-committees

The basic idea is that every sub-committee (alternatively called panel) should review a more or less similar number of observing proposals, in order to achieve a distribution as even as possible of the workload. The present nine scientific categories used for the classification of the observing proposals are therefore abandoned and replaced by six new ones[1], where the grouping of the subjects is somewhat different; one sub-committee being appointed for each of the following categories:

- *A – Galaxies, Clusters of Galaxies, and Cosmology*
- *B – Active Galactic Nuclei and Quasars*
- *C – Intergalactic and Interstellar Mediums*
- *D – High-mass and/or Hot Stars*
- *E – Low-mass and/or Cool Stars*
- *F – Solar System*

The sub-categories included in each of these main categories are detailed in Table 1. Due to the reduced number of proposals submitted for *Solar System* studies (always less than 30 per semester), these are reviewed by a smaller panel. Figure 2 shows how the proposals received for Periods 51 and 52 could be redistributed, using the new classification scheme. With the exception of category F, the histograms reveal a rather well balanced distribution of the proposals between the new scientific categories.

2.2 Composition of the sub-committees

The increase in the number of submitted proposals (Fig. 1), indicates that very soon, about 600 applications for observing time will have to be reviewed by the OPC. Assuming that these will essentially be distributed within the five new main categories, the A, B, C, D and E sub-committees will each receive about 120 ± 20 applications per semester (cf. Table 1).

On this basis, considering that a number of 60, to a maximum of 80, proposals can be reviewed by each referee, and that each proposal is given to 3 referees, the A, B, C, D and E sub-committees have been assigned 6 members each. Two of them are current OPC members, i.e. representatives nominated by the respective national committees and/or members-at-large nominated by the Director General. They serve five years, not immediately renewable. The chair rotates between these two members only. The four other members are "expert advisers" selected by the Director General in consultation with the OPC chairman without nationality consideration for a staggered two/three years term. ESO staff astronomers might be asked to participate as "expert advisers" if required. For the time being, three members only are in the F sub-committee, the chair and two advisers.

The chairmann of the OPC is not assigned to any of the sub-committees. His role is to coordinate the activities of the various panels when they meet, to ensure that the evaluation of the proposals is progressing properly.

2.3 The "new" Observing Programmes Committee

The final recommendation for telescope time allocation will be the responsibility of the "new" Observing Pro-

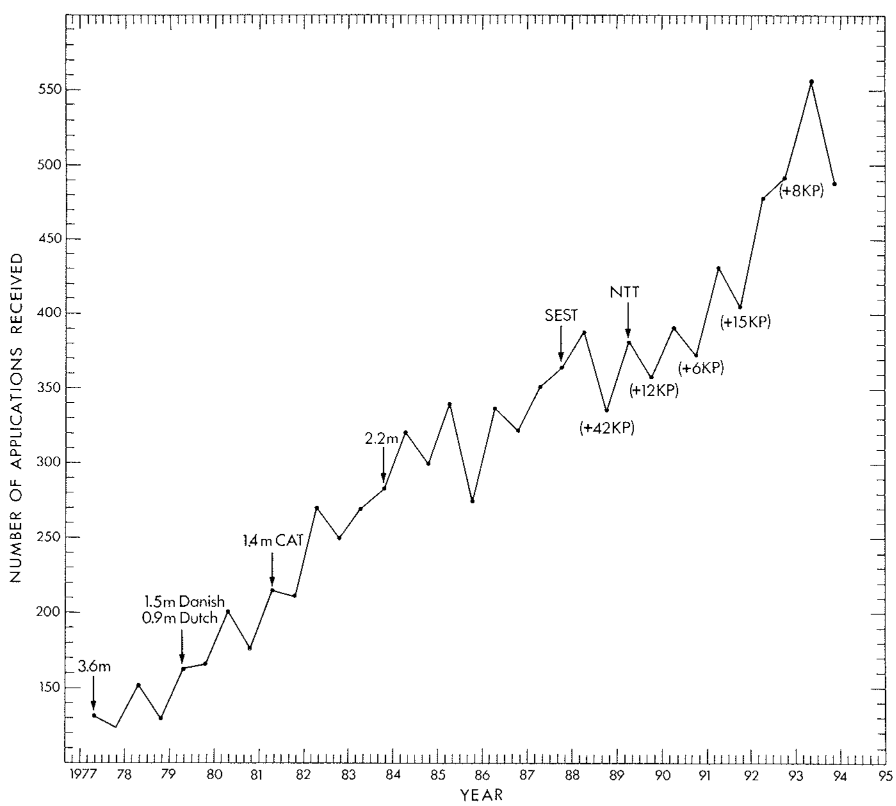


Figure 1: *Increase in the number of proposals received by ESO per observing semester. Key Programmes are marked separately. Arrows indicate when new telescopes became available.*

[1] This new classification is inspired by the one in use at the Space Telescope Science Institute.

grammes Committee composed of 12 members (8 national representatives + 4 members-at-large). The chairman is necessarily chosen among the national delegates, for its deputy there is no constraint. Both of them are appointed annually by Council.

As all the refereeing work, and preliminary ranking of the proposals, is being done by the discipline-oriented panels, there will be no further need for the presence of experts in specific areas – like SEST – during the OPC deliberation. The main task of the new Committee will be to define a unique cut-off line for every telescope after merging the recommendations made by the various panels.

The Director General and/or the Associate Director for Science as well as the ESO scientist responsible for the Visiting Astronomer's Programme attend the OPC meeting.

3. Refereeing Work

The procedure in use at the moment for evaluating the relative scientific merits, and for ranking the submitted proposals, although not perfect, has nevertheless proved to be rather efficient over the past decade. The need for a fundamental change essentially originates from the fact that the number of proposals to handle is now too large for the number of referees involved in the work. In consequence, the existing OPC procedure will basically be applied at the level of the sub-committees with, however, some amendments to eliminate the recognized weaknesses of the current system.

TABLE 1. *New OPC Categories and Subcategories*

Categories	Subcategories
Galaxies, clusters of galaxies, and cosmology	nearby galaxies, stellar populations, galaxy morphology, peculiar/interacting galaxies, bulges, core, and nuclei of nearby galaxies, kinematics of galaxies and clusters of galaxies, cooling flows, galaxy surveys, distance scale, large scale structure, distant galaxies, evolution and cosmology, gravitational lensing, microlensing
AGN and quasars	starburst galaxies, BL Lac, Seyfert galaxies, active nuclei galaxies, galactic jets, quasar absorption and emission lines, host galaxies, radio galaxies, high-redshift galaxies, quasar surveys, gravitational lensing, microlensing
Interstellar and intergalactic mediums	circumstellar matter, planetary nebulae, novae and supernova remnants, gas and dust, giant molecular clouds, cool and hot gas, diffuse and translucent clouds, cooling flows, star forming regions, globules, protostars, HII regions, quasar absorption lines
High-mass and/or hot stars	pre-main sequence stars, TTauri stars, HH objects, outflows, stellar jets, upper-main sequence stars, mass-loss, winds, WR stars, LBV stars, novae and supernovae photometry, pulsars, massive and eruptive binaries, X-ray binaries, CVs, white dwarfs, neutron stars, black hole candidates, young star clusters (open), OB associations
Low-mass and/or cool stars	low main-sequence stars, subdwarfs, brown dwarfs, circumstellar disks, early evolution, stellar atmospheres, chemical abundances, post main-sequence stars, giants, supergiants, AGB stars, stellar activity, pulsating/variable stars, binaries, old star clusters (globular), blue stragglers, astrometry
Solar system	planets, comets, minor planets and asteroids

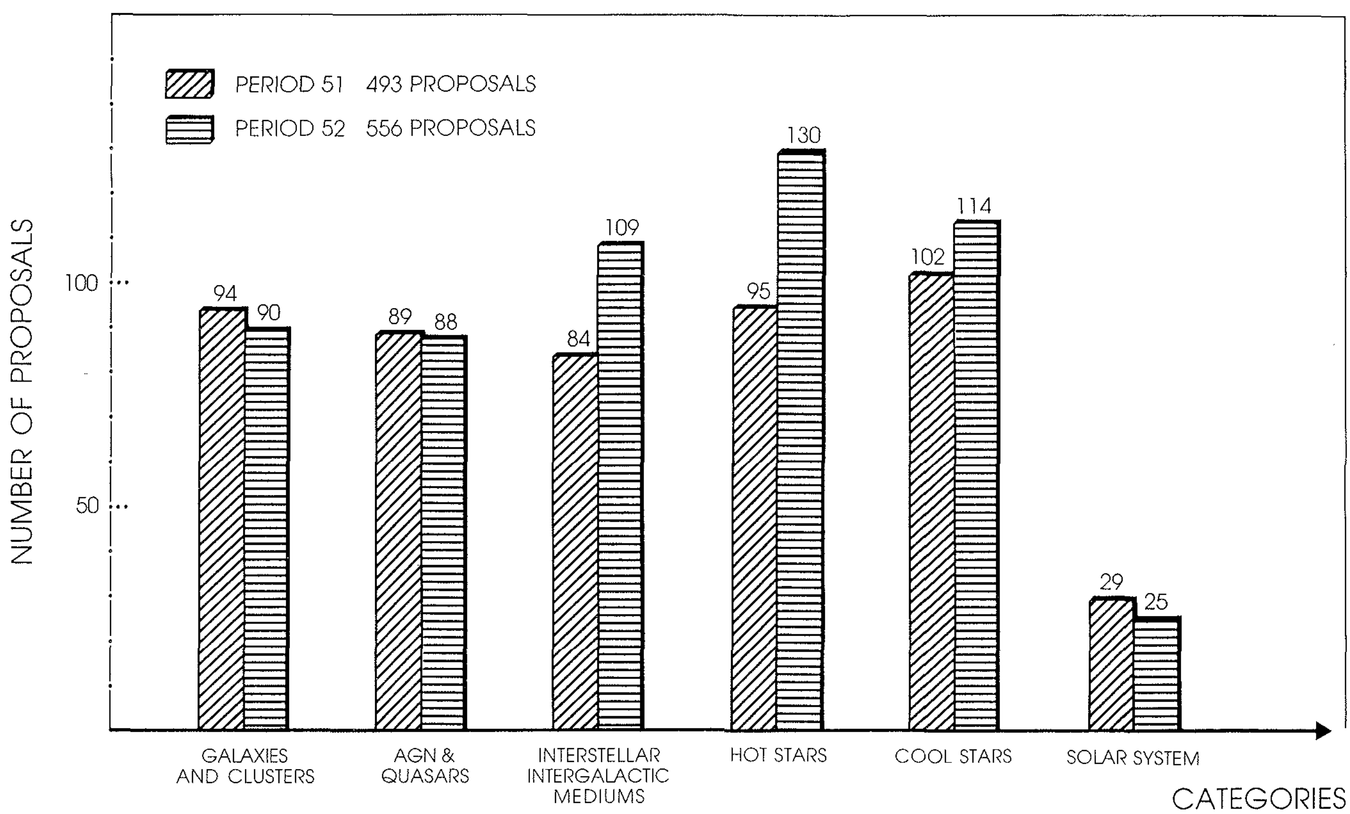


Figure 2: *Distribution among the six new scientific categories (cf. Table 1) of the observing proposals received for Periods 51 and 52.*

3.1 Panel review of the proposals

Every panel member will receive the complete set of proposals corresponding to his discipline with indication of the ones (about 60) he has to referee within three weeks, and those for which he is primary reviewer (about 20). In view of their small number, the *Solar System* proposals are all evaluated by the three members of panel F.

Once the ratings and recommended numbers of nights from every referee are available, one week before the panel meetings, ESO produces per discipline and for each telescope a list in which the programmes are ranked according to their average grade (3 referees per proposal). The average recommended number of nights is used to sum up the observing time required as one goes down the list, and a cut-off line is drawn when the number of nights "reserved" for the discipline is reached.

Due to the existence of the six panels, the definition of the cut-off line for a given telescope, at the discipline level, obviously requires some special attention. Based on time allocation statistics over the past two or three years, an average number of nights to be assigned per semester to a discipline will be derived for each telescope. This will help defining a preliminary cut-off line per telescope and per discipline, each panel having nevertheless the freedom to select more proposals, if justified by the large number of excellent programmes received. The reverse is also possible, i.e., less proposals recommended for time allocation by the panel than allowed by the position of the cut-off line.

A major change compared to the current procedure is that every referee will now have to submit in written form to the chair of the panel the arguments for his grades and recommended amount of observing time. Another important modification with regard to the present situation is the disappearance of selective discussion of proposals. In the new system all proposals will be discussed.

All technical and instrumental related issues for feasibility of the submitted programmes will have to be clarified during the panel meetings. Whenever necessary, the "technical cost" of proposals will also be evaluated. This means that each panel has (i) to identify the programmes requesting either a special equipment or an ESO instrument the use of which implies a deviation from the standard block scheduling, (ii) to make a recommendation on whether or not the required extra technical effort appears justified, considering the scientific merit of these programmes.

When the panels have completed the review of their respective set of proposals, every chair has to hand over to the ESO responsible for the Visiting Astronomer's Programme, for each telescope, a revised classification of the submitted proposals which reflects the final decision of the panel.

3.2 Final OPC recommendation

At the OPC meeting, the following new documents are distributed to the members of the Committee:

- for every telescope, a classification list of the programmes resulting from the merging of the priority lists from the panels,
- a set of tables showing, for each telescope, how the programmes above the cut-off line are distributed over the months and the moon phases, and the pressure on the various instruments.

For each telescope, the cut-off line is now defined by the number of nights available for astronomical observations, the technical time being considered separately. At this stage, it is quite clear that a number of programmes selected by the various panels will be located below the cut-off line. Under the guidance of the OPC chairman, the main and difficult task of the committee members is then to harmonize their views and decide which of the programmes in the "grey zone" have to be saved and which have to be discarded. The final product of this meeting must indeed consist of a realistic list of proposed allocations.

To achieve this goal, a mechanism similar to the one used by the HST Time Allocation Committee is foreseen. Each of the six chairs is asked to describe two proposals in his discipline: one immediately above the cut-off line and one immediately below. Programmes with the same mean grade are taken first. Once the six disciplines have been reviewed, each OPC member is requested, through a vote, to select 6 proposals among the 12 presented. Only the 6 best-ranked proposals are kept for the next iteration. The process is stopped as soon as the situation is judged satisfactory for the telescope under consideration. The exercise is then repeated for the next telescope.

Final Remark

This change in the structure and functioning of the OPC will become effective for the spring meeting (May 24–27, 1994) of the Committee.

The strong reduction in the number of applications to be reviewed by every referee that the present scheme allows, should contribute to maintain and possibly reinforce the confidence in the refereeing work done by the OPC.

The fact that the intended new procedure can to some extent be based on the system currently in use – corrected from its weaknesses – is certainly an asset. Another advantage is that external referees are not any longer needed for reviewing the key programmes. The same uniform treatment can be applied to both current proposals and key proposals, thus eliminating biases in the grading.

Adjustment in the OPC and sub-committees composition will be required as soon as national members are replaced, or when delegates from new countries become officially involved in the refereeing of the scientific programmes.

Meeting on Key Programmes

C. CÉSARSKY, J. BREYSACHER and R. KUDRITZKI

Following a "Preliminary Enquiry" carried out in 1988, the key programme scheme was introduced at ESO starting from Period 43 (April 1–October 1, 1989). Taking advantage of the addition of the NTT to the La Silla telescope park, the Director General, Prof. H. van der Laan, proposed an experiment: to allocate the extra observing time in a revised manner, "such that a number of programmes can receive very substantial portions of time". Key programmes were not expected to be a "long-term" acquisition "of large databases", but to address "a major astronomical theme, providing very specific goals and outlining a structural research strategy" (*The Messenger*, No. 51). The foreseen implementation time of a given key programme was between one and four years.

In the period between April 1989 and October 1993, 83 key programmes were proposed, of which 33 were accepted (Table 1 and 2). In the intervening semesters, 16 to 31 % of the time at the 3.6-m telescope, 14 to 26 % of the time at the NTT, and 14 to 28 % of the time at the 2.2-m telescope were attributed to key programmes. Originally, the small telescopes were not offered for key programmes, but eventually they were involved more and more heavily. (Fig. 1). Meanwhile, the number of ordinary proposals submitted to ESO continued to increase steadily, year by year.

By 1993, the time had come to assess the results of the key programme "experiment", and to take advantage of the experience gained to devise new rules. No new key programme proposals were solicited, and, at the request of the Observing Programmes Committee, the ESO Science Division and the Visiting Astronomers Section organized an informal review of all ESO key programmes, ongoing or completed.

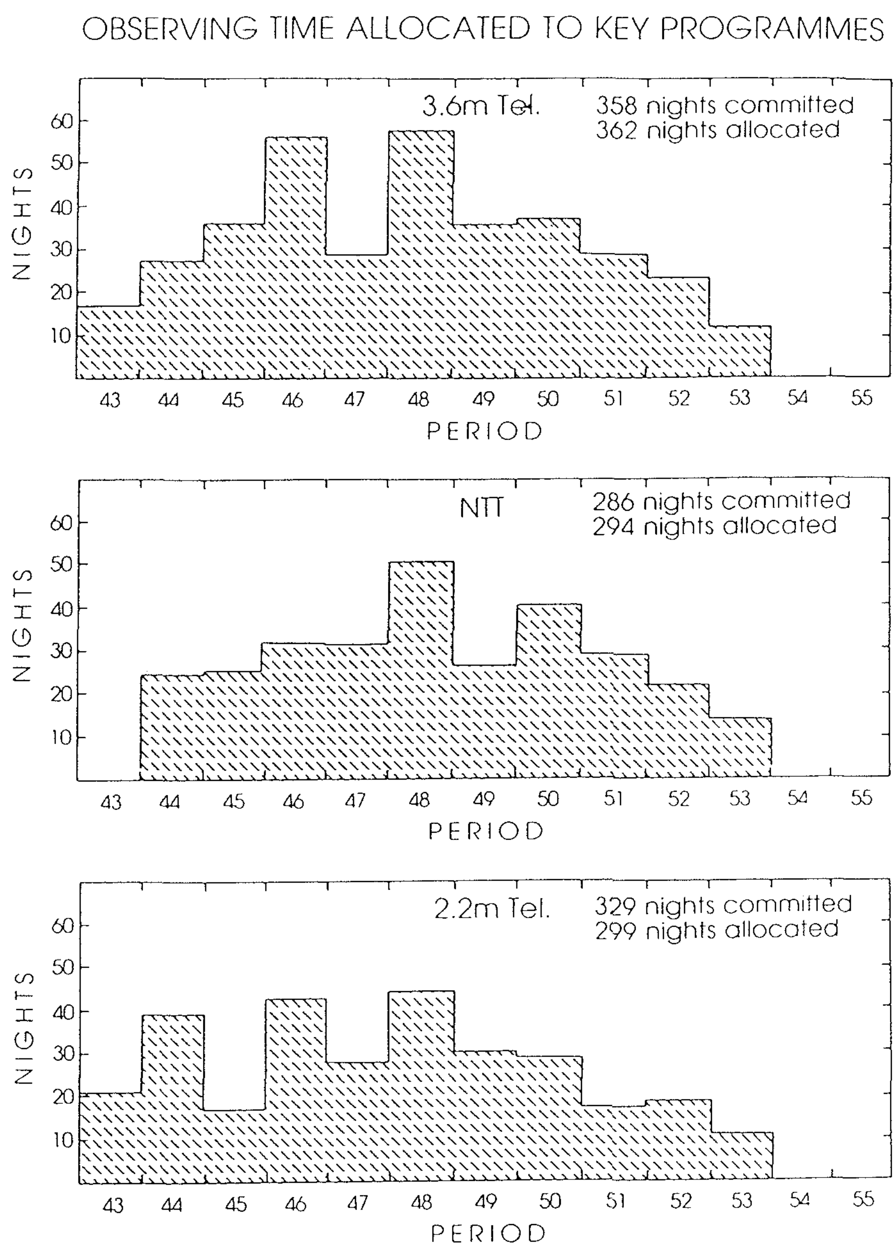
The meeting took place in Garching on November 22 and 23, 1993. The principal investigators of the 33 key programmes were given 15 minutes each to present a digest of their results, and to comment on possible difficulties encountered during the execution of the programme. In addition to the principal investigator and some of their co-investigators the meeting was attended by the Director General, Prof. R. Giacconi, members of the ESO scientific staff, the members of the OPC and a group of distinguished astronomers.

The presentations were followed by an extended and lively discussion between the audience and a panel consisting of six invited astronomers (R. Kudritzki (chair), J. Andersen, G. Gilmore, J. Lequeux, A. Renzini and P. van der Kruit), six principal investigators of key programmes (J. Bergeron, B. Fort, M. Mayor, G. Miley, R. Reimers and G. Vettolani), and the OPC chair.

A prevailing opinion in the panel and the audience was that too many of the programmes had not been of the fundamental character expected. Also, it was felt that too many key programmes were running simultaneously, so that each of them had not sufficient observing time per semester and extended over too long a period. At the same time, everybody agreed that a large number of very interesting results had been obtained; in fact, by gathering representatives of all fields of astrophysics the meeting was an excellent opportunity to informally review scientific results obtained with ESO facilities. From that point of view the meeting was exciting and successful.

The meeting ended with a closed session, chaired by C. Césarsky, where the Director General, the panel and the OPC members issued recommendations for ESO key programmes in the future:

(1) The idea of key projects (KP), granted to programmes of exceptional scientific interest and well adapted to the ESO facilities, should be retained. The KP programmes are to be performed on the three main ESO telescopes (NTT, 3.6-m, 2.2-m).
(2) Only a few KPs (of the order of three or four) should be carried out simultaneously in a given period. KPs should be achieved in a relatively



Also allocated:	1.5m Tel.	:	329 nights
	1.5m D. Tel.	:	222 nights
	1m Tel.	:	147 nights + 7 months (DENIS project)
	0.9mDu. Tel.	:	85 nights
	0.5m Tel.	:	27 nights
	G P O	:	15 months (EROS project)
	S E S T	:	84 hours / semester

Figure 1.

TABLE 1. *Distribution of the accepted key programmes*

OPC Categories	No. of KPs	
	accepted	completed*
1. Galaxies, Clusters of Galaxies	10	7
2. Quasars, Seyferts, Radio Galaxies	6	2
3. Magellanic Clouds	2	1
4. Interstellar Matter	2	1
5. Star Clusters, Galactic Structure	5	2
6. X-Ray Sources	2	1
7. Stars	3	2
8. Miscellaneous	3	1
Total	33	17

* at the end of Period 52

TABLE 2. *Number of key programmes*

Programmes	Received	Accepted	Completed	Running
Period 43 (1.4.89–1.10.89)	42	12	–	12
Period 45	12	10	–	22
Period 47	6	3	2	23
Period 49	15	5	3	25
Period 51	8	3	3	25
Period 53 (1.4.94–1.10.94)	–	–	9	16

Observing time committed: 1795 nights
+8 months/year at the 1-m telescope (DENIS project)
+24 months at the GPO (EROS Project)
+84 hours/semester at SEST

short time (appr. 2 years), not counting an initial test run, if necessary. The total amount of observing time per period spent on KPs should remain within a TBD percentage of the total available time.

(3) The applicants of a KP have to demonstrate that they have or can have the means to achieve their scientific goals, including access to data reduction software and hardware and to theoretical models.

(4) Once the OPC selects a KP, the ESO staff decides on its feasibility – after which ESO is committed to ensure that the KP receives proper support from ESO.

(5) While a given total number of nights is assigned once the KP is accepted, this number is only indicative. KPs are reviewed every year by the OPC; for this purpose the recipients have to submit in advance a written report, and have also to make an oral presentation at the OPC meeting. The number of nights assigned to the programme in the following year is fixed at that meeting. Loss of observing time due to bad weather is completely taken into account.

(6) The data obtained are the property of the KP team for one year after the last observations have been taken, after which they become public through ESO.

(7) "Long-term Projects" are not KPs. (But perhaps they should be recognizable in a more obvious way at the proposal level.) The OPC decides at each meeting whether they should continue. It is hoped that the new working structure of the OPC will make it easier to maintain continuity and memory.

(8) Extended projects of fundamental character, carried out on small telescopes, are not KPs, but "Special Projects". ESO is not committed to support them to the extent they support KPs and the applying groups are encouraged to take in charge as much as possible of the work required.

ANNOUNCEMENTS

IMPORTANT NOTICE

Please remember that the deadlines for Applications for Observing Time at La Silla have been changed to April 1 and October 1.

The deadline for Period 54 (October 1, 1994–April 1, 1995) is now April 1, 1994, and the deadline for Period 55 (April 1–October 1, 1995) is October 1, 1994.

Council and Committee Members in 1994

Council

Belgium:	J. P. Swings
	E.L. van Dessel
Denmark:	H. Jørgensen
	H.Grage
France:	C. Césarsky (Vice-President)
	J. Fouan
Germany:	M. Grewing
	A. Hansen
Italy:	F. Pacini
	C. Chiuderi
	E. Campo
The Netherlands:	E.P.J. van den Heuvel
	J. Bezemer
Sweden:	B. Gustafsson
	B. Brandt
Switzerland:	G. Tammann
	P. Creola (President)
	St. Berthet (Observer)
Portugal:	F. Bello (Observer)

Committee of Council

J.P. Swings	E. Campo
H. Grage	J. Bezemer
J. Fouan	B. Gustaffsson, B. Brandt
A. Hansen	P. Creola
F. Pacini*	

Scientific Technical Committee

J. Andersen* (1992–96)	T. Lago (1991–95) (Observer)
S. Beckwith (1994–98)	B. Marano (1993–97)
A. Blecha (1992–96)	S. Ortolani (1993–97)
R. Braun (1993–97)	J.W. Pel (1992–96)
K.S. de Boer (1991–95)	Ch. Sterken (1990–94)
D. Dravins (1993–97)	L. Vigroux (1990–94)
R. Foy (1990–94)	

Finance Committee

Belgium:	H. van den Abbeele/
	P. Grognard
Denmark:	B.K. Rosengreen
France:	P. Laplaud/M. Nauciel
Germany:	B. Schmidt-Küntzel/M. Stötzel
Italy:	U. Sessi
The Netherlands:	J. Bezemer
Sweden:	J. Gustavsson*
Switzerland:	A. Augustin
Portugal:	F. Bello (Observer)

Observing Programmes Committee

Members	*Substitutes*
C.-J. Björnsson (1993–97)	E. van Groningen
J. Lequeux (1994–96)	M. Gérin
G. Chincarini (1992–96)	G. Vettolani
Knude (1994–98)	N.N.
J. Krautter* (1992–96)	Th. Gehren
W. Schmutz (1993–97)	Y. Chmielewski
E.L. van Dessel (1990–94)	C. Arpigny
F. Verbunt (1993–97)	J. Lub
T. Lago (1993–96) (Observer)	
	P. Barthel, Member at large
	B. Pagel, Member at large
	R. Sancisi, Member at large
	C. de Bergh, Member at large

Users Committee

N. Bergvall (1993–96)	N.N.
J.V. Clausen (1991–95)	N.N.
M. Dennefeld* (1992–95)	P. Magain (1991–94)
S. Di Serego Alighieri (1993–96)	H. Zinnecker (1992–95)

*Chairman

Time-Table of Council Sessions and Committee Meetings

March 29	Finance Committee
April 28	Council
May 2–3	Users Committee
May 5–6	Scientific Technical Committee
May 9–10	Finance Committee
May 24–27	Observing Programmes Committee
June 7–8	Council
November 3–4	Scientific Technical Committee
November 7–8	Finance Committee
November 22–25	Observing Programmes Committee
Nov. 30–Dec. 1	Council

Programmes Approved for Period 53

KEY PROGRAMMES

ESO No.	Principal Investigator	Title of submitted programme	Telescope
1-003-43K	de Lapparent et al.	A redshift survey of galaxies with $z \leq 0.6$ using multi-slit spectroscopy	NTT
1-012-43K	Bergeron et al.	Identification of high redshift galaxies with very large gaseous halos	NTT

ESO No.	Principal Investigator	Title of submitted programme	Telescope
1-023-49K	Böhringer et al.	Redshift survey of ROSAT clusters of galaxies	3.6m, 2.2m, 1.5m
2-001-43K	Miley et al.	A study of the most distant radio galaxies	NTT
2-007-43K	Cristiani et al.	A homogeneous bright quasar survey	2.2m, 1.5m, 0.9mDu
2-009-45K	Reimers et al.	A wide angle objective prism survey for bright QSO	3.6m, 1.5m, 0.9mDu
3-001-43K	Israel et al.	CO as a tracer for the molecular content of the Magellanic Clouds	SEST
4-004-51K	Turatto et al.	A photometric and spectroscopic study of supernovae of all types	3.6m, 2.2m, 0.9Du
5-001-43K	Mayor et al.	Radial velocity survey of southern late type Hipparcos stars	1.5m Danish
5-004-43K	Gerbaldi et al.	Astrophysical fundamental parameters of early-type stars of the Hipparcos Survey	1.5m
5-005-45K	Hensberge et al.	High precision radial velocity determinations for the study of the internal kinematical and dynamical structure and evolution of young stellar groups	3.6m
7-009-49K	Oblak et al.	CCD and conventional photometry of components of visual binaries	0.5m, 0.9mDu
9-002-49K	Epchtein et al.	Deep near infrared survey of the southern sky (DENIS)	1m
9-004-51K	Ferlet et al.	Is our halo dark matter made of compact objects?	GPO

The Comet Shoemaker-Levy-9/Jupiter collision (joint programme coordinated at ESO by R.M. West)	08030	Millimetre observations of post-impact molecules (SEST). IR observations (3.6m, NTT). CCD imaging, photometry, and spectrophotometry (1.5m Danish). Imaging of the Io Plasma Torus (1.5m Danish). Accurate pre-impact astrometry of S-L 9 (1.5m Danish). Imaging and surface polarimetry of the dust, and Fabry-Perot interferometry of the gas in S-L 9 with a specialized focal reducer (1m). Search for differences in the optical emission of the individual nuclei of S-L 9 (1.5m). High speed photometry of light echoes from impact of S-L 9 on Jupiter (1m).

Name(s)	ESO No.	Title of submitted programme and telescope(s)
Abbott/Pasquini/Fleming	06002	Time-Series CCD Photometry of Cataclysmic Variables Discovered by ROSAT (0.9m Dutch).
Acker/Stenholm/Stasinska/Gesick/Tylenda/Gorny	04027	Galactic Bulge Planetary Nebulae: Physical and Chemical Properties (Wolf-Rayet Nuclei) (1.5m).
Ageorges/Monin/Menard/Eckart	07124	Two-Dimensional Speckle Polarimetric Observation of Young Stellar Objects (3.5m NTT).
Ageorges/Monin/Menard/Eckart	07123	High Angular Resolution Survey of Polarized Southern Pre-Main Sequence Stars (3.5m NTT).
Albrecht/Kollatschny	02017	Spectropolarimetry of Broad-Line Radio Galaxies (3.6m).
Alcaíno/Liller/Alvarado/Wenderoth	05064	Search for White Dwarfs and Eclipsing Binaries in Globular Glusters (3.5m NTT).
Andreani/Dall'Oglio/Pizzo/Whyborn/Booth/Boehringer/Nyman/Shaver	01042	The Sunyaev-Zeldovich Effect in Southern Clusters of Galaxies (SEST).
Baluteau/Joubert/Cox/Armand	04028	Physical Conditions in and around Compact HII Regions (2.2m).
Barbon/Notni/Rafanelli/Schulz/Radovich	02043	Polarimetry of the Extranuclear Regions of Starburst Galaxies (3.6m).
Barbuy/Maeder/Medeiros	07034	CNO in Yellow Supergiants (1.4m CAT).
Barbuy/Ortolani/Bica/Milone	05014	Medium-Resolution Spectra of Bulge Globular Cluster Stars for Population Synthesis (1.5m).
Bardelli/Zucca/Vettolani/Zamorani/Collins/Scaramella	01104	Study of the Galaxy Distribution in the Shapley Concentration (3.6m).
Bedding/von der Lühe/Zijlstra/Quirrenbach/Eckart/Tacconi-Garman	07127	High-Resolution Infrared Interferometry Among Evolved Stars (3.5m NTT).
Bergeron/Le Brun	01026	Identification of the Gaseous Systems Detected by their CIV and Ly-alpha Absorption in the Quasar Spectra of the HST KP (3.5m NTT).
Beuzit/Lagrange/Malbet/Tessier/Vidal-Madjar/Ferlet/Lecavelier/Hubin	07104	Search for Disks around Main Sequence Stars Using Adaptive Optics in the Infrared (3.6m).
Bignami/Caraveo/Mereghetti/Gouiffes	06009	Search for Pulsations in the proposed Optical Counterpart of PSR 1509-58 (3.6m).
Bobrowsky/Grebel/Roberts	04014	Proto-Planetary Nebulae: Search for Direct Evidence of Common Envelope Evolution (3.6m).
Boffin/Abia/Jorissen	07023	Study of the Variability of the Li I Feature in a Sample of Carbon Stars (1m, 1.4m CAT).
Bohlender/North	07009	Magnetospheres of Helium-Weak Stars in the Sco-Cen Association (1.4m CAT).
Bonfanti/Rampazzo/Reduzzi	01085	Using Ellipticals in Pairs as a Probe of the Universality of the Fundamental Plane (1.5m).
Bouvier/Montmerle/Casanova/Martin E.	07136	Low-Resolution Spectroscopy of Optically Faint ROSAT X-ray Sources in the Rho Oph (1.5m).
Brandner/Reipurth	07107	Pre-Main-Sequence Binaries and Early Stellar Evolution (3.5m NTT, 3.6m).
Cacciari/Bragaglia/Fusi Pecci/Carretta	05012	Spectroscopic Study of Blue Horizontal Branch Stars in Globular Clusters (1.5m).

Name(s)	ESO No.	Title of submitted programme and telescope(s)
Caon/D'Onofrio	01065	"Global Mapping" Photometry of the Brightest Galaxies in Nearby Abell Clusters (1.5m Danish).
Capaccioli/Piotto/Aparicio/Bresolin	01017	Cepheid Variables in the Sculptor Group Galaxies (3.5m NTT).
Carollo/Danziger/Sparks	01061	Search for Star-Formation in Dust Lanes of Ellipticals (2.2m).
Carrasco/Loyola	07008	UBVRI Photometry of FK5 Faint Stars (0.5m).
Cayrel de Strobel	07118	Fine Structure of the HR Diagram of Stars Belonging to the Thin and Thick Disk and to the Galactic Halo (1.4m CAT).
Cayrel/Nissen/Beers/Spite F./Spite M./Andersen/Nordström/Barbuy	07094	Survey of Very Metal-Poor Stars and Nucleosynthesis in the Galaxy (1.5m).
Chin/Whiteoak/Mauersberger/Wilson/Henkel	*04025*	*CN Chemistry and Extragalactic* $^{12}C/^{13}C$ *Ratios (SEST).*
Chini/Krügel/Kreysa	07076	Large Dust Grains around Solar Type Stars (SEST).
Chini/Krügel/Kreysa	01048	Star Formation Efficiency in Spiral Galaxies (SEST).
Cimatti/Di Serego Alighieri/Fosbury	02019	When Did the Distant Radio Galaxies Form? (2.2m).
Cimatti/Van der Werf/Shaver/Di Serego Alighieri	02020	CO Emission in Distant Radio Galaxies (SEST).
Cox/Bachiller/Huggins/Forveille	04052	A Complete CO Map of the Helix (SEST).
Cox/Bronfman/Roelfsema/Martin-Pintado/Bachiller/Cernicharo	07139	Radio Recombination Lines in Eta Carinae (SEST).
Cunow/Naumann/Ungruhe/Sommer	01021	Magnitude Calibration for Homogeneity Studies of the Universe (0.9m Dutch).
Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle/Chugai	03007	SN 1987A (SEST, 1.5m Danish, 2.2m, 3.6m).
Danziger/Carollo	01033	Optical and Infrared Colour Gradients in Early-Type Galaxies (1.5m Danish, 2.2m).
Danziger/Gilmozzi/Zimmermann/Hasinger/MacGillivray	06020	The Origin of the Extragalactic X-ray Background: Optical Identification of Deep ROSAT Observations in Pavo (3.6m).
De Angelis	08010	Photometric Study of the Asteroid 1620 Geographs (0.5m).
De Grijs/Van der Kruit/Peletier	01006	Optical Surface Photometry of Egde-on Spiral Galaxies (1.5m Danish).
De Winter/Grady/Thé/Grinin/Perez	07105	Disentangling the Photometric Variations of Intermediate-Mass Young Stars and Guiding Satellite Observations (0.5m Danish).
De Winter/Tambovtseva/Grinin/Perez/Grady	07114	Exploring and Modelling the Spectroscopic Variations of Bright Herbig Ae/Be Stars (1.4m CAT).
Della Valle	07100	Spectroscopy of Recent Novae Observed at La Silla (1.5m).
Della Valle/Bianchini/Dürbeck/Ögelman/Orio	07102	Novae as Standard Candles: Calibrations of Nova Shells (3.6m).
Di Martino/Zappalá/Uras/Farinella/Cellino/Barucci/Lazzarin	08005	Spectroscopic Observations of Family Asteroids (1.5m).
Di Serego Alighieri/Cimatti/Fosbury	02015	Improving the Unified Models for the Most Luminous AGN (2.2m, 3.6m).
Dubath/Meylan	05047	Velocity Dispersion Field in the Cores of High-Concentration Globular Clusters (3.5m NTT).
Ducourant/Hawkins	07044	Measurement of Parallaxes of 30 Brown Dwarf Candidates (1.5m Danish).
Dürbeck/Leibowitz/Vogt	07053	Orbital Periods, Superhump Periods and Masses of SU UMa Type Dwarf Novae (0.9m Dutch).
Duquennoy/Mayor	07087	Stellar Duplicity of Very Low Mass Stars (1.5m Danish).
Durouchoux/Vilhu/Wallyn/Grindlay/Rubio	06001	Search for e+ Annihilation Sites Near Black Hole Candidates (SEST).
Eckart/Genzel/Hofmann/Drapatz/Sams/Tacconi-Garman	*05059*	*Proper Motions in the Galactic Centre (3.5m NTT).*
Eckart/Zinnecker/Leinert	07121	The Binary Frequency among X-ray Selected Weak-line T Tauri Stars (3.5m NTT).
Edvardsson/Feltzing/Gustafsson/Lambert/Morell/Tomkin	07056	Europium and Carbon in the Galactic Disk (1.4m CAT).
Emerson/Teixeira	04045	A 1.3mm Survey of Embedded Young Stellar Objects in Vela, Lupus, Norma & CrA (SEST).
Falomo/Scarpa	02023	Spectral Properties of HPQs (1.5m).
Fasano/Falomo	02012	Optical Properties of FR-I Radio Galaxies (2.2m).
Favata/Barbera/Micela/Sciortino	07018	Lithium Abundance Determination in a Sample of Volume Limited Main Sequence K Stars (1.4m CAT).
Felenbok/Balkowski/Batuski/Maurogordato/Olowin/Singlend	01035	Spectroscopy of Two Southern Supercluster Candidates (3.6m).
Ferraro/Guarnieri/Origlia/Testa/Moneti	05046	Near-IR Imaging of Galactic Globular Clusters (2.2m).
Festou/Stern/Weintraub	09005	Mapping of the Extended Dust Clouds Around alpha PSA (Formalhaut) and beta Pic at 1.3mm (SEST).
Fort/Bonnet/Kovner/Mellier	01082	Detection and Measurement of the Gravitational Shear around Magnified Radio Sources (3.5m NTT).
Fosbury/Cimatti/Di Serego Alighieri	02021	Extended UV Continua in Nearby Radio Galaxies (3.5m NTT).
Franceschini/Andreani/Clements	01041	The Distribution of FIR/mm Light in Galaxy Discs (SEST).
François/Danziger/Buonanno/Fusi Pecci/Matteucci/Marconi	05063	Abundances in a Distant Globular Cluster Ruprecht 106 (2.2m).
Franx	01080	Evolution of Galaxies from Galaxy Kinematics at z = 0.3 (3.5m NTT).
Freudling/Alonso/Da Costa/Wegner	01081	The Peculiar Motion of Galaxies (1.5m Danish, 1.5m).
Friedli/Martinet/Wozniak/Blecha/Pfenniger/Bratschi	01008	Bars within Bars and Dynamics of Inner Region in Spiral Galaxies (1.5m Danish).
Garay/Gomez/Rodriguez	04011	Molecular Gas toward OH/IR Stars Associated with High Velocity Maser Outflows (SEST).

Name(s)	ESO No.	Title of submitted programme and telescope(s)
Giallongo/Cristiani/Fontana/Savaglio/Trevese	02039	The Physical State of the Gas in Galaxies at High Redshifts (3.5m NTT).
Grebel/Calzetti/Sokolowski/Roberts	01072	Starburst Galaxies: High Resolution Studies of Dust and Superwinds (3.6m).
Gredel/Kopp	04002	CO Multi-Line Studies towards Southern OB Associations (SEST).
Group for Long Term Photometry of Variables	07025	Long-term Photometry of Variables (0.5m Danish).
Guibert/Alard/Terzan/Bienayme/Bertin	05048	Photometric Calibration for Faint Bulge Variable Stars (1.5m Danish).
Guibert/Bienayme/Robin/Gazelle/Valls-Gabaud/Alard/Paillous/Tajahmady/Bertin/Terzan	05045	Microlensing and the Galactic Disk Missing Mass Problem (Schmidt).
Häfner/Barwig/Mantel/Hawkins	07091	Search for Eclipses in Faint Cataclysmic Variables (0.9m Dutch).
Häfner/Simon/Fiedler/Sturm	07035	Binaries with Early Type Components (0.5m).
Hainaut-Rouelle/Hainaut/Detal	08027	Pole Determination of Selected Asteroids (0.5m).
Hainaut/West	08025	Physical Properties of the Kuiper Belt Member Candidates (3.6m).
Hawkins	07015	Infrared Colours of Very Low Mass Stars and Brown Dwarfs (2.2m).
Heber/Dreizler/Napiwotzki/Rauch/Werner	07045	NLTE-Analyses of Hot post-AGB Stars of Population II (3.5m NTT).
Heidt	02036	Microvariability in X-ray Selected BL Lac Objects (1.5m Danish).
Held/Piotto	01083	Deep CCD Photometry of the Tucana Dwarf Spheroidal Galaxy (2.2m).
Henkel/Chin/Whiteoak/Mauersberger/Langer/Wilson	04010	Oxygen Burning in Massive Stars: Examining Sulfur Nucleosynthesis (SEST).
Henning/Martin K./Stecklum	04019	Probing Interstellar Dust by NIR Spectrometry (3.5m NTT).
Heydari-Malayeri/Lequeux/Le Bertre	03001	Diffuse Interstellar Bands toward Compact Massive Star Clusters of the Magellanic Clouds (3.5m NTT).
Hirth/Mundt/Eislöffel	07021	High Spatial Resolution Studies of Outflows from Young Stellar Objects (3.6m).
Hofmann/Eckart/Genzel/Drapatz/Sams/Tacconi-Garman	05058	High Spatial Resolution NIR Imaging Polarimetry of the Galactic Centre (3.5m NTT).
Holweger/Rentzsch-Holm	07001	High-Resolution Spectrometry of Sharp-Lined A Stars (1.4m CAT).
Hutsemekers/Van Drom/Remy	02016	Polarization Properties of BAL QSOs (3.6m).
Infante	01034	High Resolution Imaging of Galaxies and Arcs in CL0017 (3.5m NTT).
Infante/Fouque/Quintana	01087	Dynamics in Medium z Clusters (3.6m).
Jablonka/Kotilainen/Mellier	01079	Infra-Red Spectroscopy of Gravitational Arcs (3.5m NTT).
Jorissen/Mayor/North	07007	The Evolutionary Status of S Stars and Dwarf Barium Stars (1.5m Danish).
Jourdain de Muizon/D'Hendecourt/Schmitt B./Trotta	04037	Search for Solid Molecular Hydrogen in Molecular Clouds (3.5m NTT).
Knude	05007	Density Variation and the Absence of Dark Matter in the Galactic Disk (1.5m Danish).
Kohoutek	04022	Spectroscopy of Questionable Planetary Nebulae mainly towards Galactic Bulge (1.5m).
Krautter/Pasquini/Metanomski/Schmitt	07132	Nature of Late-Type stars in the ROSAT All-Sky Survey (0.5m, 1.4m CAT).
Krügel/Chini/Kreysa	07077	Protoplanetary Disks around Main-Sequence Stars (SEST).
Kürster/Hatzes/Cochran/Dennerl/Döbereiner	07064	High Precision Stellar Radial Velocities, Part IV (1.4m CAT).
Kunkel/Zinnecker/Schmitt	06017	Optical and Infrared Photometry of Pre-Main Sequence X-ray Sources in the ScoCen OB Association (0.9m Dutch, 1m).
Kunkel/Zinnecker/Schmitt	06016	Optical Identification of Pre-Main Sequence X-ray Sources in the Sco-Cen OB Association (1.5m).
Labhardt	01045	Deep BVRI Photometry of the HST Targets NGC 4496 and NGC 4536 (2.2m).
Laerkvist/Dahlgren/Williams I./Fitzsimmons	08008	Rotational Properties and Shapes of Hilda Asteroids (0.9m Dutch).
Lagerkvist/Magnusson/Erikson	08013	Pole Orientations and Shapes of Asteroids (0.5m, 1m).
Lagerkvist/Mottola/Di Martino/Neukum	08003	Physical Study of Trojans and Outer Belt Asteroids (0.9m Dutch).
Lagrange/Corporon/Bouvier	07103	The Spectroscopic Binarity of Ty CrA (1.4m CAT).
Lecavelier/Lagrange/Vidal-Madjar	07129	Infrared Imagery of Protoplanetary Disk: 68 Oph and alpha PSa (3.6m).
Leinert/Weitzel	07036	A Systematic Search for Low-Mass Companions to Nearby K and M Dwarfs (3.5m NTT).
Lemoine/Ferlet/Vidal-Madjar/Emerich	04051	The Isotopic Ratio of Interstellar Lithium (3.6m).
Lennon/Mazzali/Castellani/Pasian/Marconi/Bonifacio	03006	High Resolution Spectroscopy of B-Stars in NGC 330 (3.6m).
Liller/Alcaíno/Alvarado/Wenderoth	05065	UBVRI Photometry of Globular Cluster Standard Stars (1m).
Lin Yun	07099	Near-Infrared Imaging of Young Stellar Objects in BOK Globules (2.2m).
Lopez/Mekarnia/Lefevre/Starck/Danchi/Townes/Bester/Dougados/Ghez/Perrin	07115	Near-Infrared High Angular Resolution Imaging of Dust Shells Around Late-Type Stars (3.6m).
Lorenz/Drechsel/Mayer	07082	Absolute Dimensions of Early-Type Binaries (0.5m, 1.4m CAT).
Lutz/Genzel/Drapatz/Cameron/Harris/Najarro/Hillier/Kudritzki	09001	He I Stars as Contributors to the Galactic Centre Energetics (3.5m NTT).
Lutz/Sternberg/Genzel/Krabbe/Blietz	01003	NIR Spectral Mapping of Starburst Galaxies (3.5m NTT).
Macchetto/Giavalisco/Steidel/Sparks	01077	Ultra-Deep Multicolour Broad-Band Imaging of Cluster Galaxies at Redshift z~3.4 (3.5m NTT).
Magnan/De Laverny/Mennessier	07013	Study of the Repeatability of the UBVRI Light Curves of Mira Variables in Successive Cycles (0.5m).
Mamon/Holl/Deul/Robin	05051	Crowded Star Fields in the Near Infrared (2.2m).
Marconi/Tosi/Greggio	01024	Stellar Populations in Irregular Galaxies (2.2m).
Martinet/Friedli/Wozniak/Pfenniger/Bratschi	01009	1.25 to 2.2 micron imaging of barred galaxies (2.2m).

Name(s)	ESO No.	Title of submitted programme and telescope(s)
Mathias/Gillet	07130	Wave Propagation in the beta Cephei Star alpha Lupi (1.4m CAT).
Mathys/Hubrig/Landstreet/Lanz/Manfroid	07028	Systematic Search and Study of Ap Stars with Magnetically Resolved Lines (1.4m CAT, 1.5m).
Mauersberger/Henkel/Wilson/Whiteoak/Chin	04024	The Origin of the Peculiar Solar Elemental Abundances (SEST).
Mauersberger/Henkel/Whiteoak/Tieftrunk	01053	Sub-mm Observations of Dense Gas in the Starburst Galaxy NGC 4945 (SEST).
Megeath/Wilson	07133	A CO (3-2) Search for Circumstellar Disks around Southern PMS Stars (SEST).
Megeath/Wilson	07108	2 micron Spectroscopy of Young Southern Clusters (2.2m).
Mekarnia/Dougados/Ghez/Lagage/Lefevre/ Lopez/Perrin	07098	Mid-Infrared Imgaging of Circumstellar Envelopes around Evolved Late-Type Stars (3.6m).
Melnick/Heydari-Malayeri/Proust	01089	The Primordial Helium Abundance (3.5m NTT).
Menard/Léna/Catala/Monin/Bouvier/Malbet/ Schuster	07078	Deep High-Angular Resolution Imaging of Selected Young Stellar Objects with COME-ON PLUS (3.6m).
Mendes de Oliveira	01090	A Study of Emission Line Spiral Galaxies at Redshifts 0.2 to 0.4 (3.5m NTT).
Mendez/Kudritzki/Roth/Muschielok/Hamann/ Gabler	07022	Spectrophotometry of Central Stars of Planetary Nebulae in the Galactic Bulge (3.5m NTT).
Metcalfe/McBreen/Bouchet/Smith N./Hanlon/ O'Flaherty	02013	Simultaneous IR, Radio and CGRO Observations of BL Lac Objects (2.2m).
Meylan/Djorgovski/Thompson/Smith J.	02063	A Search for Quasar Protoclusters at High Redshifts (3.5m NTT).
Meylan/Dubath/Mayor	05060	A Complete Census of High-Velocity Stars in the Core of the Globular Cluster 47 Tucanae (1.5m Danish).
Miley/van Ojik/Roettgering	02031	The IR Continuum Alignment of High Redshift Radio Galaxies (2.2m).
Minniti	05016	Kinematics of Bulge Giants and the Formation of the Galaxy (3.6m).
Minniti/Claria	05033	The Age of the Galactic Bulge (2.2m).
Mirabel/Dottori/Duc	01076	Dwarf Galaxies in Tidal Tails (3.5m NTT).
Mirabel/Duc	06015	Infrared Counterparts of Black Hole Candidates (2.2m).
Moeller/Warren	01070	Searches for High-Redshift $z > 2$ Lyman alpha Galaxies (3.5m NTT, 3.6m).
Molaro/Pasquini/Castelli/Bonifacio	07111	Beryllium Abundance in Halo Dwarfs (3.6m).
Molaro/Primas/Castelli/Bonifacio	07112	Searching for the Second Stellar Generation (3.6m).
Molinari/Chincarini/Governato	01020	Spectral Atlas of the S0781-S0783 Supercluster $z \sim 0.25$ (3.5m NTT).
Moorwood/Van der Werf/Oliva/Kotilainen	02006	Role and excitation of hot molecular gas in AGN's and starburst galaxies (2.2m, 3.5m NTT).
Motch/Hasinger/Pietsch	06019	Optical Study of a new Accreting Black Hole Candidate (3.5m NTT).
Nußbaumer/Mürset/Schild/Schmutz	07083	Wind Structure of Red Giants in Symbiotic Systems (1.4m CAT, 3.5m NTT).
Olofsson/Eriksson/Gustafsson/Olander/ Schwarz	07059	Imaging of Circumstellar Envelopes in Resonance Scattered Light (1.4m CAT, 3.6m).
Origlia/Fusi Pecci/Ferraro	05009	High Resolution Mid-IR Imaging of Galactic Globular Clusters (3.6m).
Ortolani/Barbuy/Bica	05050	JHK Photometry of Reddened Bulge Globular Clusters and Nearby Fields (2.2m).
Ortolani/Barbuy/Bica	05019	Globular Clusters in the Galactic Bulge (1.5m Danish 3.5m NTT).
Pakull/Pietsch/Kahabka	06012	X-ray Source Population of the SMC (2.2m).
Palazzi/Penprase/Casey	04020	High Resolution Spectroscopy of Central Stars in Reflection Nebulae (1.4m CAT).
Pallavicini/Haisch/Schmitt/Rosner/Pasquini	06003	Chromospheres, Coronae and Winds of Cool Giants (1.4m CAT).
Pasquini/Molaro	05030	Li Abundance in Turnoff Stars of NGC 6397 (3.5m NTT).
Pasquini/Randich/Andersen	07073	Hunting Young, Nearby G Stars (0.5m, 1.4m CAT).
Paunzen/Weiss/Kuschnig	07068	Pulsation among lambda Boo Stars (0.5m).
Petitjean/Carswell/Rauch	02007	The Very Weak CIV Absorption Line-Systems (3.6m).
Piotto/Ferraro/Origlia/Palazzi	01016	Near-Infrared Observations of Cepheids in Local Group Galaxies (2.2m).
Plets/Waelkens/Van Winckel	07061	Search for the lambda Bootis Phenomenon in Herbig-Ae Stars (1.4m CAT).
Pont/Mayor	07047	Accurate Masses of Late-Spectral Type Stars (1.5m Danish).
Poretti/Bossi/Mantegazza/Zerbi	07017	Pulsation Mode Identification of Multiperiodic Delta Sct Stars (0.5m, 1.4m CAT).
Prusti/Knee	04029	The Parent Cloud of HD 104237 (SEST).
Queloz/Dubath/Mayor	01094	Duplicity and the Velocity Dispersion Gradient in the Sculptor dSph Galaxy (3.5m NTT).
Quintana/Slezak/Infante/Melnick/Bijaoui	01075	A Wide Area Survey of the Shapley Concentration: Spectroscopy (3.6m).
Quintana/Slezak/Infante/Melnick	01074	A Wide Area Survey of the Shapley Concentration: Photometry (2.2m).
Ramella/Dacosta/Focardi/Geller/Nonino/ Smith C.	01093	Redshift Survey in the Hydra-Centaurus Region (1.5m).
Rampazzo/Bland-Hawthorn/Hernquist/Bland-ford	02041	Internal Dynamics of the Luminous Infrared Galaxy NGC 6240 (3.5m NTT).
Randich/Schmitt	05038	The Very Young Open Cluster IC 2602 (3.6m).
Reduzzi/Rampazzo/Bonfanti/Sulentic	01050	Frequency and Fine Structure in Isolated Early-Type Galaxies: A Control Sample (0.9m Dutch).
Reduzzi/Rampazzo/Sulentic/Prugniel	01049	UBVRI Surface Photometry and Geometry of Binary Galaxies (0.9m Dutch).
Reimers/Vogel/Wisotzki/Surdej/Smette	02010	Absorption Lines in the New Double Quasar HE 1104-1805 AB (3.5m NTT).
Reipurth/Nyman	04046	Protostars – Further Studies (SEST).
Saglia/Bender/Gerhard	01004	Probing the Gravitational Potential and Anisotropy of Elliptical Galaxies (3.5m NTT).
Sams/Eckart/Genzel/Hofmann/Drapatz/ Tacconi-Garman	05057	High Spatial Resolution Spectral Line Imaging of the Galactic Centre (3.5m NTT).

Name(s)	ESO No.	Title of submitted programme and telescope(s)
Sams/Genzel/Beckers/Léna/Brandl	01096	Diffraction Limited K-Band Studies of High-z Galaxy Evolution and Morphology (3.6m).
Sams/Genzel/Brandl/Eckart	01097	Deep K-Band Searches for High-z in the Vicinity of Selected QSOs (2.2m).
Saracco/Iovino/Garilli/Molinari	01068	Optical Multicolour Luminosity Function of Field Galaxies (0.9m Dutch).
Schulz/A'Hearn/Stüwe	08020	Impact of P/Shoemaker-Levy 9 on Jupiter (3.5m NTT).
Seaquist/Ivison/Evans/Schwarz	07004	A Maser Survey of Symbiotic Miras (SEST).
Sembach/Danks/Caulet	04039	A Unique Probe of Diffuse Galactic Matter: Spectroscopy of Ti II (3.6m).
Shaver/Wall/Kellermann	02001	A Search for Radio-Loud Quasars at $z > 5$ (3.6m).
Siebenmorgen/Käufl	01051	The Origin of Starbursts and Infrared Emission in Galactic Nuclei (3.6m).
Siebenmorgen/Krügel/Peletier/Zeilinger	01071	Probing the Radiation Field in Active Galaxies (2.2m).
Smette/Surdej/Reimers/Wisotzki/Vogel	02057	Test of the Minihalo Model for the Ly-alpha Clouds (3.5m NTT).
Sommer-Larsen/Christensen/Beers/Flynn	05010	Bright Blue Horizontal Branch Field Stars in the Inner Galactic Halo (1.5m).
Sterken/Debehogne/Spoon	07050	Microvariations of LBVs (0.5m Danish).
Stirpe/Giannuzzo	02051	Are Narrow Line Seyfert 1 Nuclei Variable? (1.5m).
Stirpe/Santos-Lleo/Alloin	02052	International AGN Watch: Variability of the High-Luminosity AGN Fairall 9 (1.5m).
Szeifert/Baschek/Kaufer/Wolf	05023	Increasing Element Abundances Towards the Galactic Centre II (3.6m).
Szeifert/Baschek/Kaufer/Wolf	05022	Increasing Element Abundances Towards the Galactic Centre I (1.5m).
Szeifert/Baschek/Kaufer/Wolf	05021	Increasing Element Abundances Towards the Galactic Centre (0.9m Dutch).
Tacconi-Garman/Alloin/Cameron/Eckart/Genzel/Rouan	01099	Diffraction Limited Broadband Studies of the Seyfert Galaxies NGC 7469 and NGC 1068 (3.6m).
Tadhunter/Morganti/Fosbury/Shaw/Dickson/Jackson	02026	Polarimetry of a Complete Sample of Radio Galaxies: are all Radio Galaxies Giant Reflection Nebulosities in the UV? (3.6m).
Telting/Henrichs/Van Paradijs/Aerts	07065	Seismology of Rapidly-Rotating Early-Type Stars (3.6m).
Thé/Van den Ancker	05018	The Luminosity Function of Very Young Open Clusters (0.9m Dutch).
Theissen/de Boer/Heber/Möhler	07110	Do sdB Stars Always Contain Cool Binaries? (1m).
Thomas N.	08004	Longitudinal Variability of the Io Plasma Torus (3.5m NTT).
Tinney	07071	Parallaxes of VLM Stars (2.2m).
Tinney/Gemmo/Hasinger/Pietsch/Kahabka	01044	The Search for QSOs Behind Local Group Galaxies (3.5m NTT).
Tinney/Mould/Reid	05035	The Kinematics of Stars at the Bottom of the Main Sequence (3.6m).
Tsvetanov/Di Serego Alighieri/Cimatti/Fosbury	02062	Unified Model of Seyfert Galaxies: Mapping the Mirror (2.2m).
Vacca/Leibundgut	01086	High-Resolution Imaging of Wolf-Rayet Galaxies (3.5m NTT).
Van der Bliek/Gustafsson	07033	Chemical Abundances Analysis of the Royal Standard Stars for ISO (1.4m CAT).
Van der Hucht/Richter/Churchwell/De Graauw/Gredel	04032	Infrared Morphology of Ultra-Compact HII Regions (3.6m).
Van der Hucht/Williams/Gunawan/Bouchet	07066	Search and Monitoring of Eruptive Wolf-Rayet Dust Formation (2.2m).
Van der Klis/Augusteijn/Berger/Van Paradijs	06011	IR Counterparts of Highly Reddened Low-Mass X-ray Binaries (2.2m).
Van der Kruit/De Grijs/Peletier	01005	Near-Infrared Surface Photometry of Edge-on Spiral Galaxies (2.2m).
Van der Werf	02004	Search for Redshifted H alpha Emission from Damped Ly alpha Systems (2.2m, 3.5m NTT).
Van der Werf	02003	Search for Redshifted [CII] 158 Micron Emission from High Redshift QSOs (SEST).
Van der Werf/Shaver	02005	Search for Very Distant IRAS Galaxies (3.6m).
Van Dessel/Sinachopoulos	07134	CCD Photometry for the Interpretation of the Main Sequence (0.9m Dutch).
Van Paradijs/Charles/Martin A./Casares/Van der Klis	06006	Black Hole Candidates in Faint Soft X-ray Transients (1.5m Danish).
Van Paradijs/Leibundgut/Abbott/Augusteijn	07081	Supernova Lightcurves (0.9m Dutch).
Waelkens/Daems	07062	Study of the W Serpentis Star HD104901B (1.4m CAT).
Waelkens/Mayor	07060	Radial-Velocity Variations in Post-AGB Stars (1.5m Danish).
Wagner/Bock	02055	Synchrotron Spectra of Gamma-Ray Blazars (1.5m Danish, SEST).
Webb/Barcons/Bowen/Lanzetta/Tytler	01091	Dynamics of Galaxies to ~ 160h −1 kpc (3.5m NTT).
Weigelt/Appenzeller/Beckmann/Davidson/Kohl/Nußbaum/Schöller/Scholz/Van Elst/Wagner	09004	Speckle Masking and Speckle Spectroscopy of Stellar and Extragalactic Objects (3.6m).
Weiland/Becker/Großmann	01052	Molecular Cloud Complexes in the Extreme Dwarf Irregular Galaxy IC 1613 (follow-up) (SEST).
West/Hainaut/Marsden/Meech/Smette	08024	Activity in Very Distant Comets (3.5m NTT).
Wichmann/Alcalà/Covino/Krautter/Schmitt	07085	Photometry of Weak-Line T Tauri Stars in Chamaeleon and Lupus (1m).
Wiedemann	07079	Exploration of CO Fundamental Bands in Late-Type Stars (3.5m NTT).
Will/Schmidt	05015	The Shape of the IMF in Young Galactic Open Clusters at Low Masses (1.5m Danish).
Williger/Wampler/Carswell	02040	The UV Background at $z > 4.5$ (3.5m NTT).
Wolf/Kaufer/Mandel/Stahl/Gäng/Gummersbach/Sterken/Kovacs	07014	Structure and Variability of the Winds of A-Type Supergiants (0.5m).
Wouterloot/Brand	04007	CO Excitation Conditions at the Edge of the Galaxy (SEST).
Zanin/Cappellaro/Sabbadin/Turatto	04035	Spectroscopic Study of Newly Discovered, Distant Planetary Nebulae (1.5m).
Ziegler/Bender	01013	The Age of Elliptical Galaxies in Clusters (3.6m).
Zinnecker/Eckart/Ageorges/Quirrenbach	07122	Adaptive Optics Observations of Lindroos Wide Binaries (3.6m).
Zinnecker/Moneti/Wilking	07128	10 micron Photometry of pre-Main Sequence Binary Systems (3.6m).

Postdoctoral Fellowship on La Silla

A postdoctoral fellowship is offered on La Silla, starting during the last quarter of 1994. The position is open to a young PhD recipient with strong interest in optical observational astronomy. The successful applicant will have a demonstrated potential for independent as well as collaborative research within and beyond the Astronomy Support Department (ASD) of the La Silla Observatory. Research interests represented in the ASD include active galactic nuclei, star formation, planetary nebulae, abundances and activity of cool stars, magnetic stars, supernovae, and the interstellar medium. The spectrum of the observing facilities on La Silla is among the broadest currently available at ground-based observatories.

The holder of the position will spend 50 % of the time as a member of the newly formed NTT Team which comprises scientists and engineers charged with the operation and upgrading of the 3.5-m New Technology Telescope (NTT). Emphasis will be on the support of Visiting Astronomers and the monitoring of the performance and calibration of the optical instrumentation of the NTT; these duties are to be performed in close collaboration with other Team members and the technical staff of the Observatory. Familiarity with modern software utilities is a requirement.

The ESO fellowships are granted for a period of one year, normally renewed for a second and exceptionally for a third year.

The monthly basic salary will be not less than 5059 DM to which are added an expatriation allowance of 30–45 % as well as a mountain allowance of 5–10 %. Applications should be submitted to ESO not later than 15 May 1994. Applicants will be notified by 31 July 1994. Application forms are available from ESO Personnel and General Services (PGS), Karl-Schwarzschild-Str. 2, D-85748 Garching b. München, Germany. Applicants should arrange for 3 letters of reference to be sent by the same date directly to PGS.

For further information: contact the project scientist (Internet: dbaade@eso.org or SPAN: ESO::DBAADE).

ANNOUNCEMENT

ESO Workshop on SCIENCE WITH THE VLT

An international conference to highlight the observational opportunities introduced by the VLT and the 8m class telescopes.

Garching, Munich, Germany
28th June – 1st July 1994

Scientific sessions:

- Stellar populations in the Galaxy and nearby galaxies
- Star formation
- Late stages of stellar evolution
- Planetary systems
- ISM studies
- Supernovae
- Distance indicators
- Galactic nuclei and AGN
- Large scale structure
- Gravitational lensing
- The most distant galaxies and quasars

Each session will comprise a review by an invited speaker followed by contributed talks. Poster papers are also encouraged.

CONTRIBUTIONS IN THE FORM OF WORKED-OUT OBSERVING STRATEGIES for planned VLT instruments (CONICA, FORS, FUEGOS, ISAAC and UVES), or other possible instruments, are encouraged.

Closing date for applications (with or without proposed contributed papers): 30 April 1994.

Organizing Committee:

(Working Group on Scientific Priorities for the VLT)
K. de Boer (Bonn), B. Fort (Pic-du-Midi), R.-P. Kudritzki (München), B. Marano (Bologna), S. D'Odorico (ESO), L. Vigroux [Chair] (Saclay), J.R. Walsh (ESO), J. Wampler (ESO)

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ANNOUNCEMENT

ESO Workshop on QSO Absorption Lines

ESO, Garching
21 – 24 November 1994

An ESO workshop on QSO absorption lines will be held from 21 to 24 November 1994, at the Headquarters of the European Southern Observatory, Garching bei München, Germany.

The workshop is intended to discuss the theory and observations of QSO absorption lines in relation to the following topics:

- Galactic halo and interstellar medium
- Low-redshift systems
- Intrinsic absorption lines and BAL systems
- Ly-alpha clouds
- Damped systems
- Metal systems
- Probing the large scale structure
- Probing the Universe at high redshifts

Organizing Committee:
S. D'Odorico, G. Meylan, P. Petitjean, P. Shaver, J. Wampler, ESO

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New ESO Publications

(December 1993–February 1994)

Scientific Report No. 13: "A Catalogue of Quasars and Active Nuclei" (6th Edition). Eds. M.-P. Véron-Cetty and P. Véron.

Scientific Preprints

961. N.N. Chugai and I.J. Danziger: SN 1988Z: Low Mass Ejecta Colliding with the Clumpy Wind? *M.N.R.A.S.*
962. P. Dubath, G. Meylan and M. Mayor: On the Velocity Dispersion in the Core of the Globular Cluster M 15. *The Astrophysical Journal.*

963. E. Cappellaro et al.: New Emission Nebulae in the POSS Field $18^h 48^m + 0°$. *M.N.R.A.S.*
964. N.S. van der Bliek, T. Prusti and L.B.F.M. Waters: Vega: Smaller Dust Grains in a Larger Shell. *Astronomy and Astrophysics.*
965. R. Gredel, E.F. van Dishoeck and J.H. Black: Millimetre Observations of Southern Translucent Clouds. *Astronomy and Astrophysics.*
966. S. Pellegrini and G. Fabbiano: The Very-Soft X-Ray Emission of X-Ray Faint Early-Type Galaxies. *The Astrophysical Journal.*
967. A. Moneti, I.S. Glass and A.F.M. Moorwood: Spectroscopy and Further Imaging of IRAS Sources Near the Galactic Centre. *M.N.R.A.S.*
968. H.E. Schwarz: Morphology and Kinematics of Planetary Nebulae. Invited paper presented at 34th Herstmonceux Conference: "Circumstellar Media in the Late Stages of Stellar Evolution." Cambridge, UK, 12–16 July 1993.
969. P. Molaro and L. Pasquini: Lithium Abundance in a Turnoff Star of the Old Globular Cluster NGC 6397. *Astronomy and Astrophysics.*
970. F. Matteucci: Abundance Ratios in Ellipticals and Galaxy Formation. *Astronomy and Astrophysics.*
971. J. Einasto et al.: The Fraction of Matter in Voids. *The Astrophysical Journal.*
972. M. Tarenghi, B. Garilli and D. Maccagni: Galaxy Structures in the Hercules Region. *The Astronomical Journal.*
973. B. Leibundgut: Observations of Supernovae. To appear in *The Lives of Neutron Stars*, eds. J. van Paradijs and A.M. Alpar (Dordrecht: Kluwer).
974. P.A. Patsis et al.: Hydrodynamic Simulations of Open Normal Spiral Galaxies: OLR, Corotation and 4/1 Models. *Astronomy and Astrophysics.*
975. L.B. Lucy: Image Restorations of High Photometric Quality. R.N. Hook and L.B. Lucy: Image Restorations of High Photometric Quality: II. Exemples.
Papers presented at: "The Restoration of HST Images and Spectra II", a workshop at the Space Telescope Science Institute, 18–19 November 1993.
976. E. Giallongo et al.: The Gunn-Peterson Effect in the Spectrum of the $z=4.7$ QSO 1202-0725: The Intergalactic Medium at Very High Redshifts. *The Astrophysical Journal* Letters.
977. M. Della Valle et al.: The Nova Rate in Galaxies of Different Hubble Types. *Astronomy and Astrophysics.*
978. J.-L. Starck and F. Murtagh: Image Restoration with Noise Suppression Using the Wavelet Transform. *Astronomy and Astrophysics.*
979. A.F.M. Moorwood and E. Oliva: Extended Infrared Line Emission Excited by Starburst and Seyfert Activity in NGC 3256 and in NGC 4945. *The Astrophysical Journal.*
980. A.G. Gemmo and C. Barbieri: Astrometry of Pluto from 1969 to 1989. *Icarus.*
981. N. Hubin and L. Noethe: Active Optics, and Laser Guide Stars. *Science.*
982. W. Freudling, L. Nicolaci da Costa and P.S. Pellegrini: Testing the Peculiar Velocity Field Predicted from Redshift Surveys. *M.N.R.A.S.*
983. C. Aspin, Bo Reipurth and T. Lehmann: Is ESO Hα 279 a Pre-Main Sequence Binary? *Astronomy and Astrophysics.*
984. P. Bouchet et al.: SN 1987 A: Observations at Later Phases. To be published in IAU Colloquium 145 on Supernovae and Supernova Remnants. Xian, China, May 24–29, 1993. Cambridge University Press.
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