No. 67 – March 1992

FIRST 8.6-M GLASSY MENISCUS BLANK FOR THE VLT!

This picture shows the first 8.6-m glassy ZERODUR-meniscus blank after machining at the SCHOTT factory in Mainz, Germany. This blank has been annealed, lifted from the mold, turned in a specially designed turning device and put on the 8-m CNC grinding machine. The blank is illuminated from below by two lamps; the yellowish colour is that of the glass. The yellow band around the blank is for protection during the machining.

The ceramization to achieve the zero expansion coefficient of ZERODUR is in preparation and will last 8 months.

A second 8.6-m blank has also passed the annealing process and is now being machined. A third 8.6-m blank is at present in the annealing oven.

After ceramization each blank will receive a central hole and will be ground to near the final shape it must have to become a VLT meniscus-mirror blank of 8200 mm diameter and 177 mm thickness.

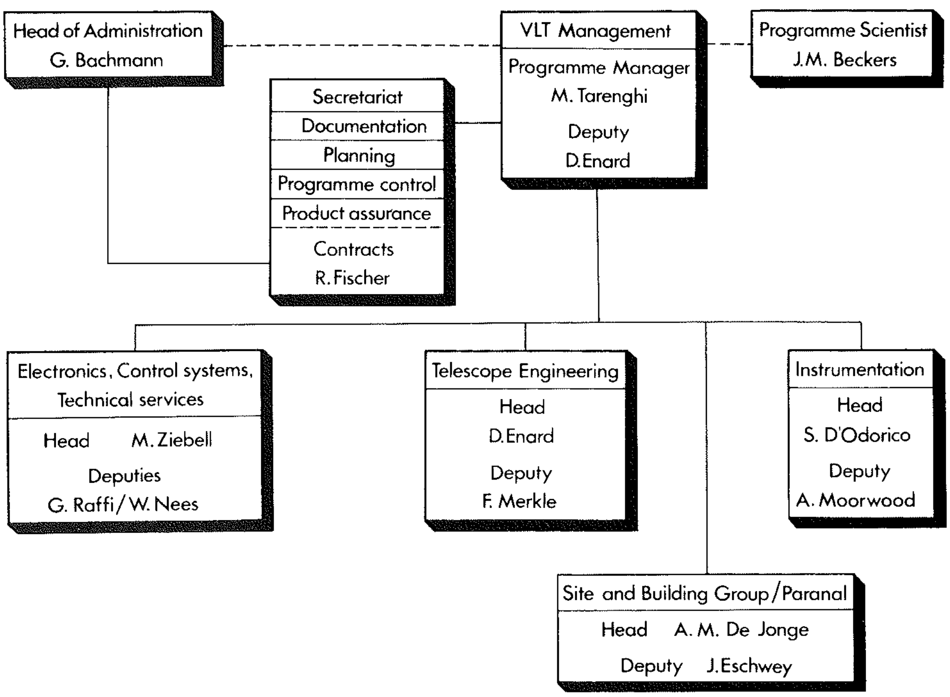
The VLT Progresses as its Programme Management is Adapted

H. VAN DER LAAN, ESO Director General

Every issue of this Quarterly in the last several years has demonstrated the progress of the VLT Programme and this one is no exception. This fifth year after the go-ahead decision of December 1987 promises to be the last in which the VLT Division, along with many in the Administration and myself, spend our time mostly in preparing Calls for Tenders and Calls for Proposals, then assessing the responses. By the end of 1991 we had contractually committed over 40 % of the VLT capital budget; by the end of this year this level will rise to 70 %, with another 15 % in the tendering process. From 1993 onwards the greater portion of the in-house engineering efforts will consist of monitoring problems and progress of both industrial and institutional contracts.

Those who think a small organization like ESO can achieve the demonstrated progress of such a large programme without difficulties, harbour illusions. In the course of 1991 we had plenty of problems to stay on course, i.e. to maintain the schedule and continue within budget while respecting our specifications. But stay on course we did, thanks to the talent and sheer dedication which mark ESO's VLT team. We had to let our programme manager, recruited in industry, go and I decided against another attempt to find outside talent. We therefore mustered inside competence, reshuffling some to put "the right men in the right place". The VLT Division is now headed by Massimo Tarenghi, who has a programme office staff to assist him in the running of the VLT Programme. Three departments make up the division's substance in Garching: Telescope Engineering headed by Daniel Enard, who also serves as Massimo's deputy; Instrumentation, headed by Sandro D'Odorico, and Electronics Systems, headed by Manfred Ziebell. The VLT construction manager is Peter de Jonge, who recently moved to Chile and will oversee all activities in ESO's Paranal area. The Contracts and Procurement Department, headed by Robert Fischer, is the VLT's prime link to the Administration. The science optimization of the VLT's design and construction progress is the responsibility of the VLT Programme Scientist, Jacques Beckers, who reports directly to me. These senior staff and their deputies are mentioned in the accompanying diagram. Not shown but very actively present is a VLT Division staff of some sixty people who thrive on the challenge to build European astronomy's most ambitious observatory yet.

THE VLT DIVISION



VLT News

M. TARENGHI, ESO

During the last few months, major milestones towards the completion of the first 8.2-m VLT mirror took place. At SCHOTT the programme of casting and machining of the 8.6-m blank is continuing as scheduled. The photo on the frontpage illustrates the progress of the activity and gives the first visual impression of this new domain in mirror technology. A long series of experiments, including tests on a 4-m spin-cast Zerodur, carried out during the past few years by SCHOTT even before the VLT contract was signed, have made it possible to control the process. In the

Figure 1: *General view of the shop with the 32-m tower. In the foreground are the meeting room and the offices. On this picture, the sunshield is under achievement and the tower has not been topped with the 4-m dome.*

Figure 2: *The width of the entrance door to the REOSC factory is 10 metres.*

Figure 3: *Milling bridge. This bridge, which has a free span of 9 metres, will be installed over the grinding machine rotating table. The picture shows the computer-controlled carriage which bears the milling head.*

course of the machining of this mirror it was possible to test extensively the handling of these large glass disks.

At REOSC the preparations necessary to receive the first blank in the spring of 1993 are continuing. The completion of the new factory and the installation of the polishing machines are presented in Figures 1–5 which were taken around mid-January 1992. The REOSC building was designed to fulfill all the technical needs for the polishing of the 8-m mirrors but at the same time it represents an interesting and futuristic architectural achievement.

The high tower contains a second tower detached from the external one on top of which all the interferometric instruments for the optical tests of the mirror will be located. Great care was taken to avoid a vibration of the inner tower and to control the air along the optical path. The large 10-m entrance door and a 36-ton crane installed inside the building will allow easy access of the track transporting the mirror box and the handling of the mirrors. Inside the building, two milling machines manufactured by INNSE (Italy) and a robot manufactured by SOCOFRAM are being installed and are expected to be tested in a short time. The existence of two machines will allow the grinding and polishing of the two mirrors in parallel reducing considerably the delivery time.

On April 24 the 8-m shop will be inaugurated by the French Minister of Research, Mr. Hubert Curien. A few weeks later the 8.2-m concrete dummy will arrive at REOSC in its transport box after a journey from Dunkirk to Paris. This will be a good test for the different transport phases on roads and rivers. The dummy will be used to test the handling of the mirror while in the factory. Later on the same dummy will be used to test the mirror cell and will probably be sent to Chile for the first integration of the telescope.

As reported in the last issue of the *Messenger*, the first of a series of explosions to remove soil took place on Paranal; this was seen by the Council members on their visit to the summit. The activities of levelling of the mountain is continuing at full speed and about half the material has been removed. An article about the geology of the area is included in the current issue of the *Messenger* and on the basis of geological analyses it was decided to remove 28 m from the summit in order to obtain a large plateau to accommodate the VLT installation.

The final configuration of the VLT site is in the process of being frozen and will take into consideration all the scientific and technical aspects required by a project of this dimension. Particular atten-

Figure 4: *Base of the polishing rotating table installed in its pit. The oil pads at the periphery of the table base are protected by grey yellowish plastic. The track is attached to the table.*

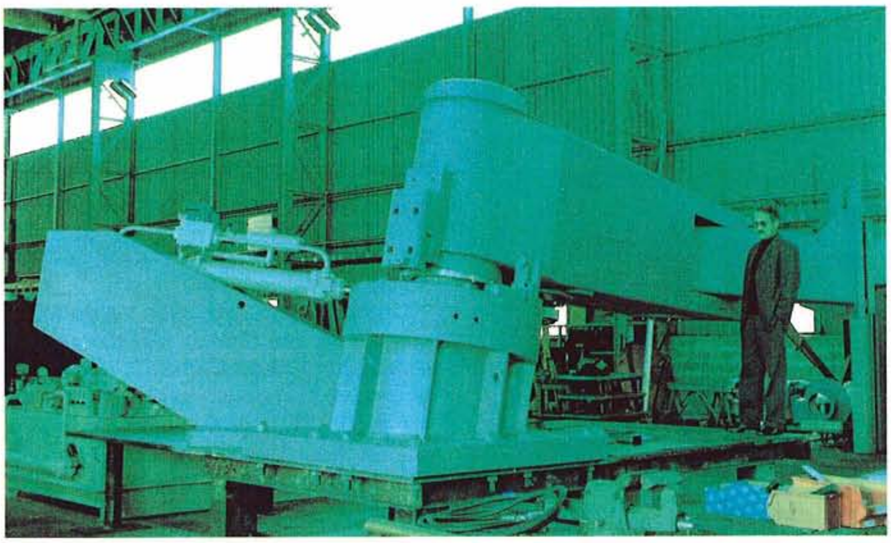


Figure 5: *The polishing robot in Bordeaux.*

tion is given to the need to maintain the summit of the mountain free from any source of disturbance for the observations.

In Denmark, COWIconsult is completing the design of all civil engineering complexes both in the hotel area and the telescope area and is preparing the technical specifications for the call for tenders that will be sent out in spring 1992. It is interesting to note that a major effort has been devoted to the requirement to keep underground all the infrastructure such as the laboratories and interferometry tunnel which need to be kept in stable thermal conditions. Another area of careful study was to create easy access to the different buildings during observation and also to simplify the transport of large pieces such as the mirror cell. In the hotel area the need to create a pleasant environment for the Paranal population has been one of the goals of the design of the offices, hotel facilities and dormitories. Also the design of the interior both from the furniture point of view and the colour scheme are part of this work and will help considerably in the future life at the observatory.

In France IRAM and STEC are collaborating in the detailed design of the VLT enclosure. A concept of a carousel type was chosen, fulfilling all the requirements of the astronomical community and giving good protection of the telescope from any source of disturbance. At the same time more analyses are being done on the effects of earthquakes on such large structures, and a wind tunnel study is foreseen to optimize the ventilation of the enclosure to reduce the dome seeing to zero.

In Italy AES is continuing the first phase of the telescope structure contract which will culminate in the preliminary design review in summer 1992.

The work done so far has concentrated on the definition of the critical components such as the direct drives which are a peculiar characteristic of the VLT, the hydrostatic bearings and the encoder system for which various technical solutions are being considered. After the preliminary design review the project foresees the detail design review for the rest of 1992 and the start of the construction early 1993. The plans for the erection in Chile in 1995 of the first telescope is confirmed and will be preceded by extensive tests of the telescope erected in Europe.

A Geological Description of Cerro Paranal or Another Insight Into the "Perfect Site for Astronomy"

*F. BOURLON, ESO**

Paranal, where the ESO Very Large Telescope project is situated, is not just any old place! It is unique because it is *the* "perfect site" for astronomy. But it is also unique because of its location in the Atacama desert. It is a place of character by its remoteness, its loneliness and its desolation. Nevertheless, it is also a place of beauty by its colours, its silence and its space. No one who comes here is left unmoved by the spectacle that unfolds in front of his eyes. Yet if we stay here long enough we realize that there is still more. There is something "deeper", something that emerges from the land and earth itself. As our perceptions become sensitized

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by the silence, we take notice of the forms, shapes and colours of every object that is present. Smooth hills roll off to the faraway Andes... The mountain range to which Paranal belongs slopes down to the west and falls dramatically into the Pacific Ocean. Cliffs and canyons cut deep into the earth in a complex manner.

While Paranal watches over the great Pacific Ocean to the west, the silent Atacama desert and the Andes to the east, questions come up. What gave rise to the round and smooth morphology of the area? What is this land made of? What dramatic events occurred to mark this place with cliffs, canyons and abrupt valleys?

In the field of Geology these questions relate to three different themes; "Morphology and Geoclimatic Activities", "Geodynamics" (or "Plate Tectonics") and "Petrography" (or "Rock Constituancy").

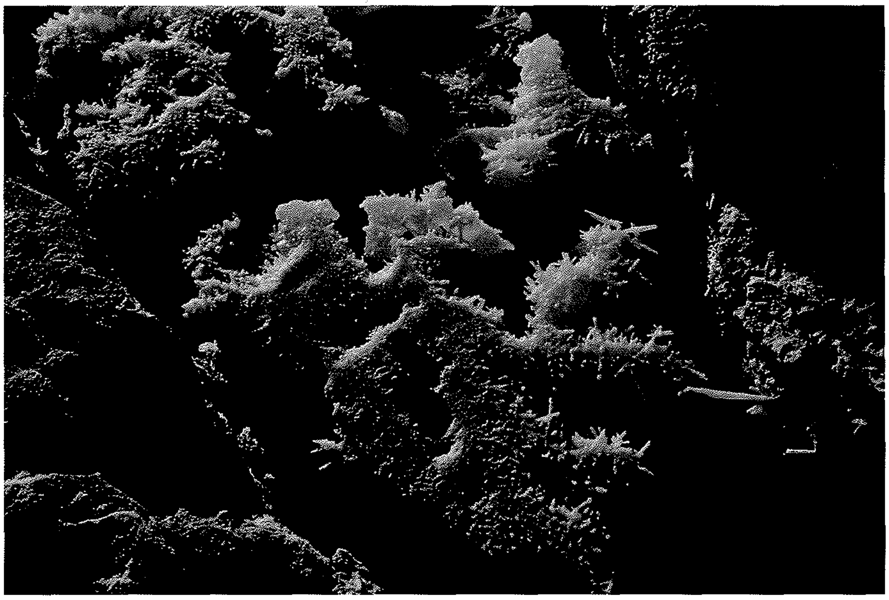


Figure 1: *Crystals of salt in a rock fracture. Such pure forms are found on the shores of "salares" (salt lakes).*

Morphology and Geoclimatic Phenomena

The landscape of Paranal is smooth and round. Hills and small mountains can be seen to the north, the south and the east. There are rocky outcrops only near the ocean coast. A wide valley, where the old Panamericana or "B70" road lies, runs almost north-south. It is bordered by hills. Boulders can be seen in the valleys or on their slopes. Some darker material spreads out on top of the general beige surface of the hill's slopes.

What first attracts the eye is the aspect of the landscape, the presence of big lonely boulders and the large deposits of eroded and alluvial material. It is puzzling to find here the marks of erosion linked to rain and water activity when we consider that we are in the Atacama desert. It is surprising but the reason is that the climate of the area has changed drastically in the last 10,000 years. Studies have shown that at a time the climate was of a glacial period. Glaciers rushed down from the high Andes to the interior valleys. The land was covered by numerous large lakes. The salars, antique lakes that have dried leaving large deposits of salt, are the clearest mark of that epoch. The Paranal zone had certainly no such glaciers because of its location near the ocean, but abundant rain and snow falls affected it. This climatic environment induced important rock alteration and modelled the landscape. The succession of heat and cold structured the rock, and the water circulation carried away material, depositing it in the valleys in the form of sands or boulders. Due to the marine air, salts (sulphides and chlorides) were deposited and then crystalized in the rock massif (Fig. 1).

At a later period the landscape was further shaped by drastically different climatic conditions. Rains became more seldom, the glaciers melted and the land dried out giving rise to the desert we know today. In this environment occurs a specific type of phenomenon called "arid weathering". It excludes movement of material except by wind effects and it mainly affects the rock's structure itself. Minerals of lesser resistance such as micas and felspars are altered into clays. The more resistant minerals such as quartz and amphiboles or pyroxenes are left uncemented and the rock loses its coherence. This phenomenon is known as "arenization" (transformation into sand) and is common in all granitic regions. Figure 2 shows the rock at the Paranal summit in such a state of decomposition. There is sand on the top layer, round large boulders below and then deeper down the still sound rock. In the current levelling works of the Paranal summit this has been described as the "weathered layer" zone. On average it constitutes the first 6 m of at the Paranal surface. This "soil" is easily removable and, for construction purposes, is unstable.

However, the two climatic phenomena that have been described – hydraulic weathering and arid weathering – do not fully explain the observed landscape.

Figure 2: *The arid weathering phenomenon: sand on the top (and at the bottom where it falls), round boulders and the "sand" rock. White, salt filled, fractures can also be seen.*

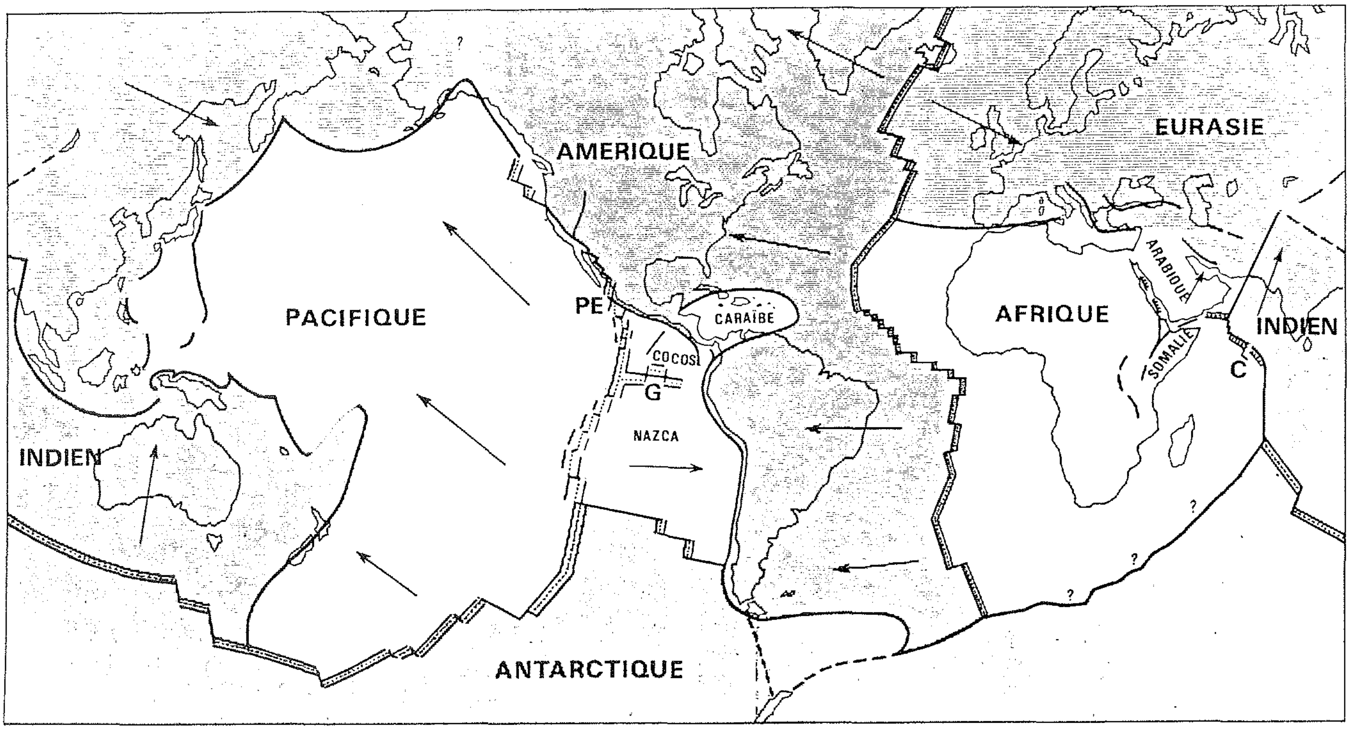


Figure 3: *Drawing showing the six main plates and some secondary ones. The movement of the plates is given considering that the African plate is immobile. The plates are generally limited by oceanic rifts or abyss. G. Galapagos rift, PE. East Pacific rift, C. Carlsberg rift. (E. Bullard modified, 1984).*

Obviously these two phenomena affected a pre-existing surface. The origin of the relief has to be linked to that of the Andes range. In reality it is a complex geological context that gave birth to this land.

Geodynamics, Plate Tectonics and the Formation of the Andes

When we stand on the summit of Paranal, looking from east to west we see the cliffs and canyons bordering the coast, a valley, a range of hills, a wide valley called Pampa Remendios on a new mountain area. We then usually take notice of the high Andes that spread far away to the east. On the horizon rises the majestic volcano Llullaillaco, with its 6738 m one of the five highest volcanos of the world.

Geographically speaking, various units constitute the Andes; the coastal mountain range ("Cordillera de la Costa"), the interior massifs (such as the "Cordillera Domeyko" or the "Sierra de Vicuna Mackenna" in the Antofagasta region) and the high range which constitutes the "Cordillera de los Andes". The Paranal mountain belongs to the Cordillera de la Costa, and is its highest point with its 2664 m. Armazones on the other hand belongs to the Sierra de Vicuna Mackena (3064 m).

The layout of these units has a logic. The Andes chain, as a whole, is the result of what is called "Plate Tectonics". The mobility of the earth crust provokes, on the scale of geological times, intense deformations that give rise to mountains in certain parts of the globe. The younger mountain ranges are situated at the boundary between a continental and an oceanic mass. In Chile the two plates that meet are the oceanic Nazca plate and the continental American plate (Fig. 3). The plunging of the Nazca plate below the South American continent is known as the Subduction phenomenon. Just like the bodies of two cars that bend as they collide, the continental South American mass and the oceanic Nazca mass bend and "fold" as they meet (Fig. 4). The folds correspond to the "Cordillera de la Costa", the "Cordillera Interior" and the Andes. This collision, and thus the formation of the Andes, began in the triasic period (225 million years ago) and continues at present (horizontal movements are estimated at 10 cm/year and the vertical ones at 2 cm/year). In comparison the formation of the Alps started in the Trias (225 MY ago) and ended during the Pliocene (7 MY ago).

The formation of these mountains induce seismical and volcanic events. The two plates in a "dead-lock" accumulate strains until the rock breaks. The plates fracture across their whole width releasing energy as shock waves. Material in fusion, situated in the earth's mantel, using the previously created fractures, flows to the surface. Lava is released in a volcanic eruption. The volcano Llullaillaco was formed that way.

These geological events moulded the landscape. In the Paranal area for example, the valleys that border the mountains or the cliffs that border the ocean correspond to faults caused by the plate's dynamics. The tens of kilometres long "Salar del Carmen" and "Izcuna" faults, located east and west of Paranal, are the borders of blocks that moved in opposite directions. Because of this dynamic the zone in which Paranal stands was literally crushed. Studying the rock at the summit of the mountain we find that it is density fractured. It was further affected when water circulation increased its erosional effect. Each fracture rendered the rock more vulnerable to weathering. As we look at the geological chronography of this land we understand the history of the modelling of the landscape. The same applies when we study the rock composition of Paranal. It is in this geodynamic context that the petrography has to be considered.

The Paranal Rock Formation

Basically three types of rock are found on the Paranal hill; Gabbros, Andesite and Granodiorites (Fig. 6).

The *Gabbro* is a dark gray rock of large-sized minerals, mainly Felspars (alumino-silicas) and Pyroxenes or Amphiboles (ferromagnesian minerals). It contains very little or no quartz (silicium). A rock containing somewhat more quartz and having a different proportion of Felspars types is a "Diorite". Because

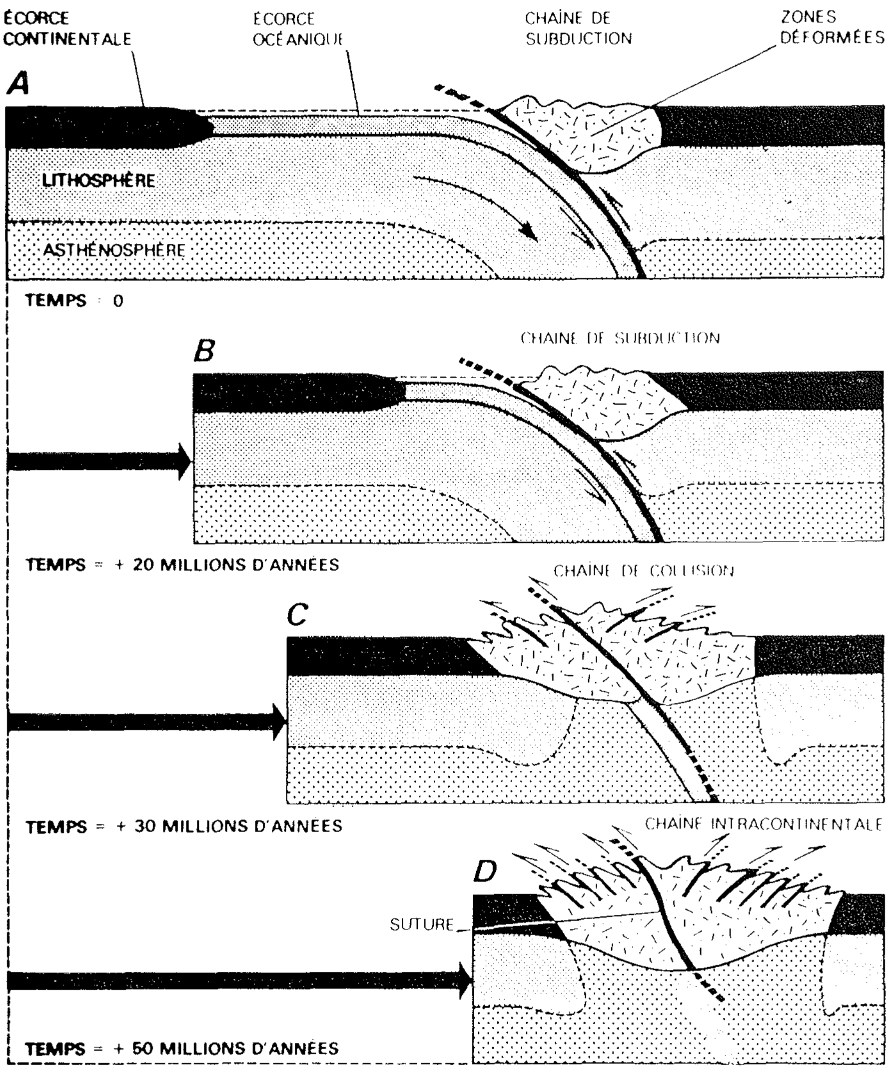


Figure 4: *Geodynamic evolution of plates in a "Subduction" zone. The time scale is only indicative. In the Nazca Plate/American plate zone, movements are estimated at 10 cm/year. (M. Mattauer, 1981).*

these chemical variations are common we sometimes speak of the "Gabbro-diorites" of Paranal.

The *Andesite* is a dark-green rock. It contains some Amphiboles (green-black ferromagnesia), very little Felspars and silicium in its amorphic form (glass). Its texture is fine and the minerals that constitute it are almost invisible. They are basalts, just like the Gabbros but have had a different formation context (lower temperatures and lower pressure). Basically the Andesite is a "surface" type of rock and solidified in a rapid way, while the Gabbro is a rock of high depth that solidified slowly. A slow cooling enables the growth of crystals (like those that are found in Gabbros), while a rapid cooling produces glass. This rock is usually found in volcanic areas.

The *Granodiorites* is a pinkish type of rock. It contains Plagioclases (a type of felspars, pink or white in a non-altered state) and quartz in a lower measure than in a Granite. It also has the textural name of "Aplites" because of their dense but very fine mineralization.

Figure 7 is a schematic association model for basaltic types of rock. On a scale that goes from some thousands of metres down up to the surface and that relates to a pressure and temperature scale, we can locate the Gabbros at medium depth and Andesites at surface level. The granodiorites are located in "Dykes" or "chimney"-like ducts that cut across the Gabbro. The Andesites can also be found in such a state (as is the case at Paranal). Simplifying one could say that the three types of rocks formed here originate from the same magmatic

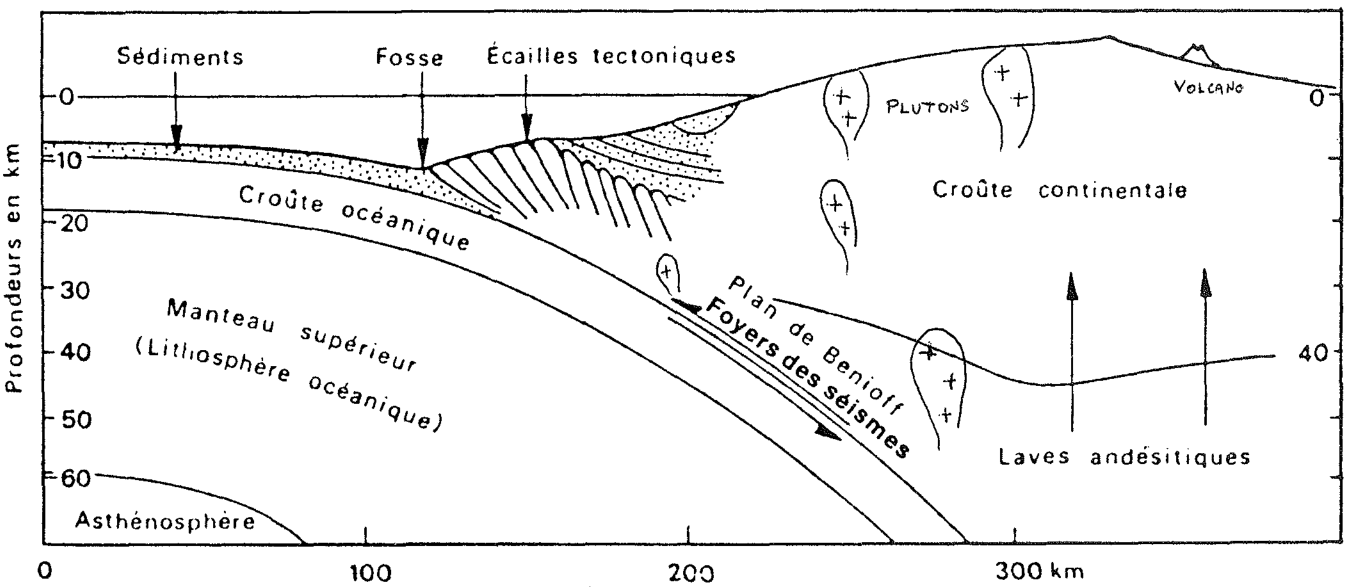


Figure 5: *Simplified cross-section of the earth crust at the occidental limit of South America (heights are exaggerated). The subduction of the Nazca plate carries earth crust and sediments down to the earth's mantel. Dehydration of the sediments liberates fluids that can cause partial fusion of the above crust. The material in fusion rises towards the continent's surface. As the material cools it crystallizes giving plutons (granitic masses). The material can also reach the surface as a lava. (Le Pichon, modified).*

Figure 6: *These are the typical rocks found on the Paranal summit; the black "Gabbro", the green "Andesite", the pinkish "Granodiorite", the green-blue copper minerals, two samples of "salt"-enriched rocks (white), a metamorphic rock with fern-like deposits of magnesium and in the centre a green-gray rock containing "Olivine" crystals.*

liquid but then evolved in different temperature, pressure and chemical environments.

Clays are occasionally found. As previously explained they originate from the alteration of the felspars contained in the rocks.

There are a few particular minerals. Such as chlorides or sulphides. Salts that were deposited in recent times by weathering effects. There are also some "rare" minerals such as Copper and Olivine. Copper is found associated to different chemical complexes and three types are found here; Atacamita, Crisocola and Calco-pyrite. These deposits are related to hydrothermal fluids, minerally charged, that circulated in present faults. Olivine on the contrary is of high temperature and pressure context and so of great depth. The rock containing such a mineral was probably brought up from deeper rock layers.

If we enlarge our scale of analysis, the geology of the area appears more complex. As we can see in the geological map (Fig. 8), sedimentary deposits (marine sediments of calcareous type), sandstones (marine or lake deposits of silicium type), intrusive rocks (typically a Granite) or mylonites (a metamorphic rock) have been found. This conglomeration of so many different types of rock, formation wise, is due to the geodynamic phenomena of the zone. The upheaval of the Andes has put into contact and intricately mixed all types of rocks. Faults and kilometre long movements have displaced blocks or enabled material from the earth's core to rise. Heating has transformed material. Friction and fracturing linked to tectonic movements affected the entire land.

Tentative Time-table of Council Sessions and Committee Meetings in 1992

May 4–5	Users Committee
May 11–12	Scientific Technical Committee
May 25–26	Finance Committee
June 2–3	Observing Programmes Committee, Amsterdam
June 4–5	Council
November 12–13	Scientific Technical Committee
November 16–17	Finance Committee
November 26–27	Observing Programmes Committee
December 1–2	Council

All meetings will take place in Garching unless stated otherwise.

Intellectual Interest and Practical Applications

Studying the geology of Paranal gives us a new vision of the site. One can really be awed by the history of the modelling of this land. But beyond the intellectual interest, this knowledge is useful. Understanding the geology of Paranal is necessary to plan the construction of the VLT. Soil mechanic studies, seismic hazard estimates, water use programmes or researches for construction materials rely fully on the correct understanding of the site's geologic or geotechnic characteristics. Knowing about the rock composition is helpful when searching for adequate sands or gravels for concrete. Understanding the recent geo-climatic environment can orientate the water supply programme. Estimating the seismic hazard risk, by statistical studies of occurred events or by monitoring seismic tremors, enables the structural design of the buildings. Testing the geotechnical quality of the Gabbros, Andesites, Granodiorites or the surface material, gives indications as to where to install and how to design the buildings' foundations. This in accordance to the resistance and stability of the terrain in such a seismic prone zone. In all, the geological understanding of the place is of vital interest. Particularly if we consider that the biggest telescope ever is being built here!

Acknowledgements

I thank S. Dunn for re-reading and correcting my "Franco-Spanish" English, and P. de Jonge and J. Eschwey of the VLT site building group for their interest.

References

Dercourt J. and Paquet J., 1985, *Géologie, Objets et Méthodes*, Dunod ed., Paris.

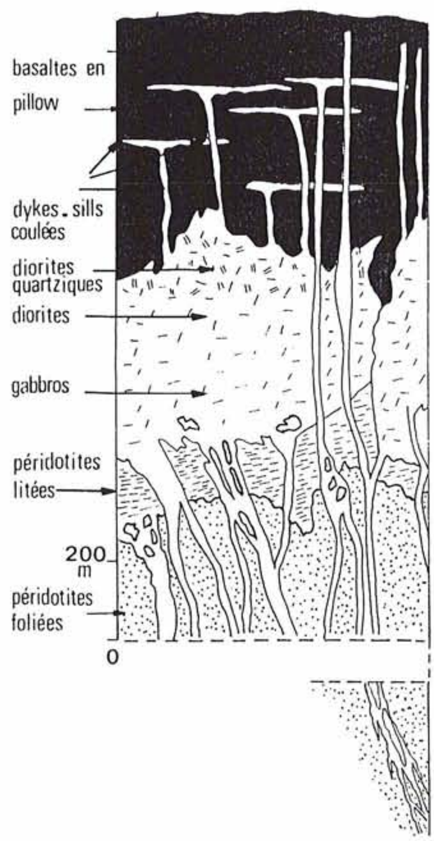


Figure 7: *Model of association of basic to ultra-basic rock occurring supposedly below the sea floor. (J. Dercourt, J. Paquet, 1985).*

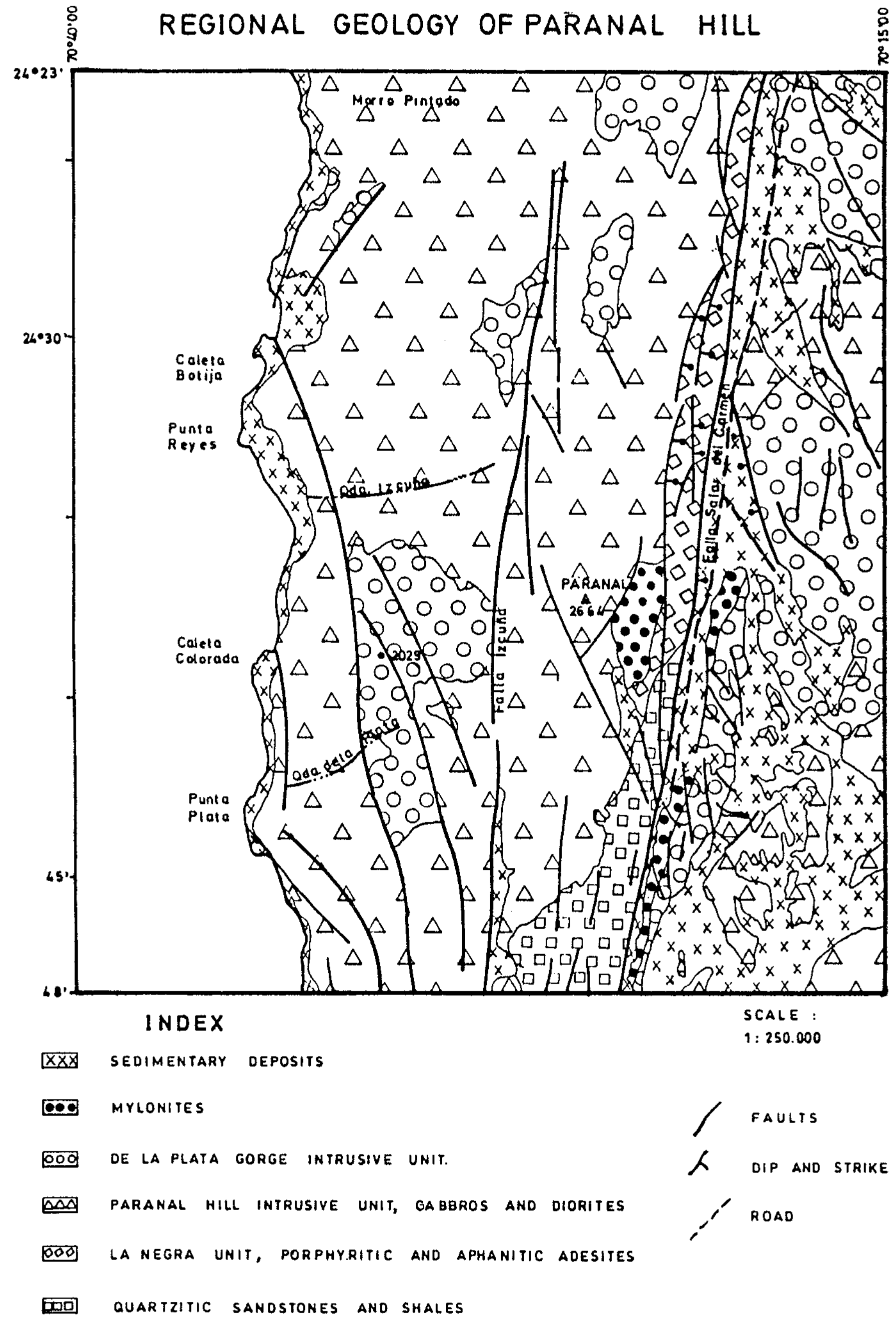


Figure 8: *Regional Geology of Paranal Hill. (F. Ferraris, 1978).*

Bellair P. and Pomerol C., 1984, *Eléments de Géologie*, A. Collins ed., Paris.

La Recherche **228**, January 1991, "Le volcanisme andin" Magazine, Paris.

Piddo J., 1990, "Geotechnic-Geological Study of Vizcachas and Paranal hills" ESO report.

Figure 3: As found in Bellair P. and Pomerol C., 1984, *Eléments de Géologie*, page 108.

Figure 4: As found in Bellair P. and Pomerol C., 1984, *Eléments de Géologie*, page 132.

Figure 5: As found in Bellair P. and Pomerol C., 1984, *Eléments de Géologie*, page 110.

Figure 7: As found in Dercourt and Paquet 1985, *Géologie, Objets et Méthodes*, page 50, chpt. 4.

Figure 8: As found in Piddo J., 1990 "Geotechnic-Geological Study of Vizcachas and Paranal hills" ESO report, Annex, plate 2.

New ESO Preprints

(December 1991 – February 1992)

Scientific Preprints

803. E. Giraud: The Environment of 3C 255. *Astronomy and Astrophysics Letters.*
804. E. Giraud: Morphology of Faint Blue Galaxies. *Astronomy and Astrophysics* Research Note.
805. F.R. Ferraro, F. Fusi Pecci and R. Buonanno: The Galactic Globular Cluster NGC 5897 and its Blue Stragglers Population. *Monthly Notices of the Royal Astronomical Society.*
806. F.R. Ferraro et al.: On the Giant, Horizontal, and Asymptotic Branches of Galactic Globular Clusters. IV: CCD-Photometry of NGC 1904. *Monthly Notices of the Royal Astronomical Society.*
807. P.A. Mazzali, L.B. Lucy and K. Butler: Barium and Other S-Process Elements in the Early Time Spectrum of SN 1987A. *Astronomy and Astrophysics.*
808. P. Padovani: A Statistical Analysis of Complete Samples of BL Lacertae Objects. *Astronomy and Astrophysics.*
809. P. Ruiz-Lapuente, L.B. Lucy and I.J. Danziger: The Use of Nebular Spectra of Type Ia Supernovae for Distance Determinations. The Distance to the Centaurus Group.
P. Ruiz-Lapuente et al.: Spectroscopic Differences Among Type Ia SNe and their Use as Standard Candles.
810. D. Baade: Nonradial Pulsations of O- and B-Stars. Invited Review presented at the Kiel-CCP7 workshop on "Atmospheres of early type stars" and to appear in the proceedings edited by U. Heber and C.S. Jeffery (Springer, *Lecture Notes in Physics).*
811. P. Ruiz-Lapuente et al.: Modeling the Iron-Dominated Spectra of the Type Ia SN 1991T at Premaximum. *The Astrophysical Journal* (Letters).
812. J. Surdej et al.: Optical Observations of Gravitational Lenses. Invited paper at the "Hamburg International Conference on Gravitational Lenses", (Hamburg, Sept. 9–13, 1991). To appear in the Conference Proceedings, Springer, *Lecture Notes in Physics* series.
813. P. Magain et al.: Q 1208+1011: The Most Distant Multiply Imaged Quasar, or a Binary? *Astronomy and Astrophysics Letters.*
814. Bo Reipurth and S. Heathcote: Multiple Bow Shocks in the HH34 System. *Astronomy and Astrophysics.*
815. L. Pasquini et al.: Detection of Strong Chromospheric and Coronal Activity in Pop II Binaries.
L. Pasquini and E. Brocato: Chromospheric Activity and Stellar Evolution: Clues from IUE Data.
R. Pallavicini et al.: A Low-Resolution Spectroscopic Survey of Post-T Tauri Candidates.
G. Tagliaferri et al.: Optical Spectroscopy of Cool Stars Detected by Exosat.
G. Cutispoto et al.: Photometry of Serendipitous X-Ray Sources.
Papers presented at the Seventh Cambridge Workshop on Cool Stars, Stellar Systems and the Sun, October 9–12, 1991, Tucson, Arizona.
816. M. Forestini et al.: Fluorine Production in the Thermal Pulses on the Asymptotic Giant Branch. *Astronomy and Astrophysics.*
817. A. Jorissen and M. Mayor: Orbital Elements of S Stars: Revisiting the Evolutionary Status of S Stars. *Astronomy and Astrophysics.*
A. Jorissen: Orbital Elements of a Sample of S Stars: Why are they not Symbiotics? Paper presented at the "XIIIe Journée de Strasbourg", Advanced Stages in the Evolution of Close Binary Stars", ed. G. Jasniewicz, Strasbourg, 1991.
818. M.D. Johnston and H.-M. Adorf: Scheduling with Neural Networks – the Case of Hubble Space Telescope. *J.*

Computers and Operations Research, special issue on "Neural Networks".

819. T. Toniazzo, M. Stiavelli and W.W. Zeilinger: Subsystems in Early-Type Galaxies: the Structure of NGC 6851. *Astronomy and Astrophysics.*
820. S.R. Zaggia et al.: High Resolution Kinematics of Galactic Globular Clusters. I. *Astronomy and Astrophysics.*
821. M.-H. Ulrich: The Nature of the Broad Line Region: Optical/UV/X-Ray Studies. To appear in the Proceedings of the 2nd Annual October Astrophysics Conference "Testing the AGN Paradigm", College Park, Maryland, Oct. 14–16, 1991.
822. A. Moneti: The Double Nature of RCW57/irs1. *Astron. and Astrophysics.*
823. J.R. Walsh, K. Ogura and Bo Reipurth: Two Remarkable Herbig-Haro Objects in the NGC 2264 Region. *Monthly Notices of the Royal Astron. Society.*

Technical Preprints

37. G. Raffi: Control Software for the ESO VLT. Paper presented at the International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPS), held in Tsukuba, Japan, November 11–15, 1991.
38. M.A. Blessinger et al.: Low Noise 256 × 256 Element MWIR Infrared Focal Plane Array for Strategic and Scientific Applications. Paper presented at 1991 meeting of the IRIS Speciality Group on Infrared Detectors held at the National Institute of Standards and Technology, Boulder, Colorado, USA, August 13–16, 1991. Sponsored by ERIM, Information Analysis Center, Ann Harbor, Michigan, USA.
39. J.M. Beckers: Removing Perspective Elongation Effects in Laser Guide Stars and their Use in the ESO Very Large Telescope. Paper to be presented at the April 27–30, 1992 ESO Conference on "Progress in Telescope and Instrumentation Technologies" in Garching bei München, Germany. At the March 10–12, 1992 "Laser Guide Star Adaptive Optics" workshop in Albuquerque, NM, USA.
40. M. Faucherre and R. Maurer: On Metrology Systems for Delay Lines. H. Jörck et al.: The Design of Delay Lines for the VLT Interferometer. To be published in the Proc. of ESO Conf. on "High Resolution Imaging by Interferometry", Garching, Oct. 14–18, 1991.
41. P. Bourlon, T. Ducros and M. Faucherre: Results of Vibration Measurements on La Silla Telescopes. To be published in the Proc. of ESO Conf. on "High Resolution Imaging by Interferometry", Garching, Oct. 14–18, 1991.
42. C. Alexandroux, J.-A. Hertig and L. Zago: Wind Tunnel Tests on a Large Astronomical Telescope. Proceedings of the "Eighth International Conference on Wind Engineering (London, Canada). To appear in *Journal of Wind Engineering and Industrial Aerodynamics.* Ed.: A.G. Davenport, Boundary Layer Wind Tunnel Laboratory, The University of Western Ontario, Faculty of Engineering Science.

VACANCY IN GARCHING

STAFF ASTRONOMER – REF. ESD204

A position as astronomer will shortly become available in the Astronomy Group of the Science Division at ESO Headquarters in Garching near Munich, Germany.

The position will be open to an astronomer with a doctorate in astronomy or equivalent and several years of post-doctoral experience as well as an excellent record in independent astronomical research. A good knowledge of English is essential.

The successful applicant will be expected to carry out an active research programme related to observational astronomy, and to make significant contributions to the duties of the Astronomy Group.

Scientific interests in the group include large-scale structure; quasars; AGNs; dynamics and chemical evolution of galaxies; supernovae and supernova remnants; variability of early-type stars; and the diffuse interstellar medium. Responsibilities include the guidance of students and junior fellows, the workshop and symposium programme, assistance to visiting astronomers using ESO's data reduction and remote observing facilities, and interaction with other groups at ESO Headquarters in matters ranging from telescopes and instrumentation to computing and image processing.

This is a tenure track position, normally offered for an initial period of three years, renewable for a second period of three years. Tenure may be granted during the second term of the contract.

Applications – stating the above mentioned reference number – should be submitted by September 30, 1992. Application forms can be obtained from:

European Southern Observatory
Personnel Administration and General Services
Karl-Schwarzschild-Strasse 2
D-8046 Garching bei München
Germany

New ESO Scientific Report on Star Forming Regions

ESO Scientific Report No. 11 "Low Mass Star Formation in Southern Molecular Clouds" appeared in January. The book contains 10 chapters, describing all the major southern molecular cloud complexes and their populations of low mass young stars. Each region is discussed by a specialist, and aims to outline our current knowledge about that star formation region, with very extensive references to the literature. The book is thus a tool that facilitates and encourages further studies of the rich southern star forming clouds. Researchers working in the field can request a copy free of charge as long as stock permits by writing to

ESO Information Service
Karl-Schwarzschild-Str. 2
D-8046 Garching bei München
Germany

Bo Reipurth, ESO

New Operating Manuals

Operating Manual No. 10: IRSPEC, eds. R. Gredel and A.F.M. Moorwood, Version No. 1, August 1991.

Operating Manual No. 14: THE OPTICAL PHOTOMETER ON THE ESO 1 m TELESCOPE, eds. H. Lindgren and F. Gutiérrez W., Version No. 1, August 1991.

STAFF MOVEMENTS

Arrivals

Europe

GENDRON, Eric (F), Coopérant
JØRGENSEN, Bruno (DK), Clerk (General Services)
KINKEL, Ulrich (D), Student
KOLB, Manfred (D), Student
LAMBERT, David (USA), Guest Professor
PATSIS, Panagiotis (GR), Fellow
RATIER, Guy (F), Associate
SIEBENMORGEN, Ralf (D), Fellow
STRIGL, Gisela (D), Laboratory Tech. (Photography)
Young, Andrew (USA), Guest Professor

Chile

GREDEL, Eva (D), Student

Departures

Europe

MESSERLIAN, Suzanne (F), Secretary
NEUMANN, Harry (D), Clerk (General Services)
PASIAN, Fabio (I), Fellow
ROCHE, Jocelyne (F), Programmer
RUIZ LAPUENTE, Maria (E), Student
STIAVELLI, Massimo (I) Fellow
THEUNS, Tom (B), Student

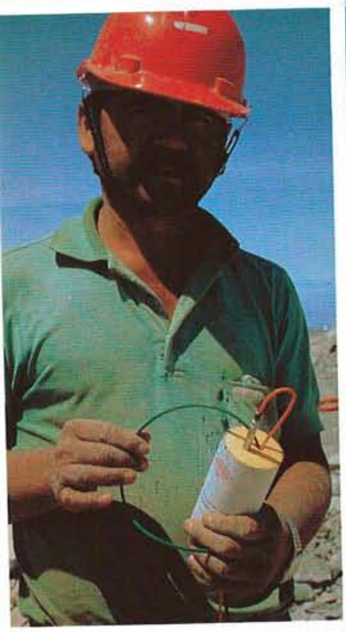
Correction

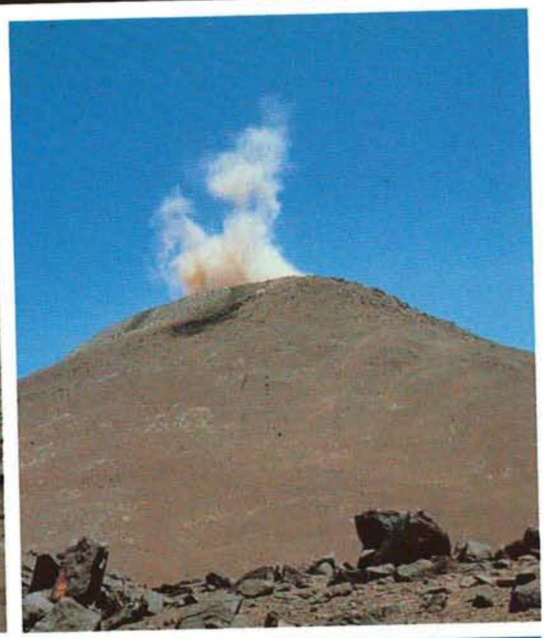
An error has been discovered in the article by K.S. de Boer et al. on "Trouble in the Magellanic Clouds!" (*The Messenger* No. **66**, p. 14). The sentence starting in line 11 in the third column on page 14 should be: "This led to estimate the total number of Hα emission-line objects in the SMC to about *4000*. . ."

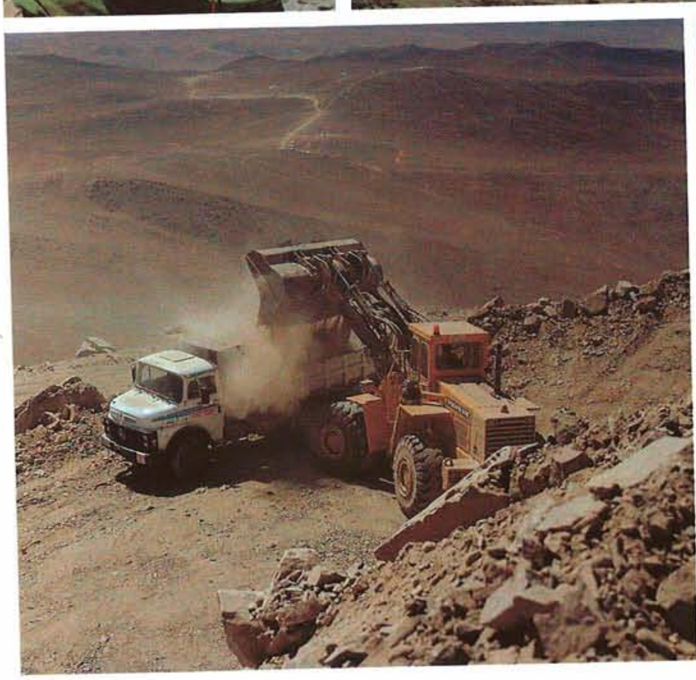
BEAUTIFUL LA SILLA. *Early evening at the SEST (photo H. Zodet).*

A Paranal Portfolio

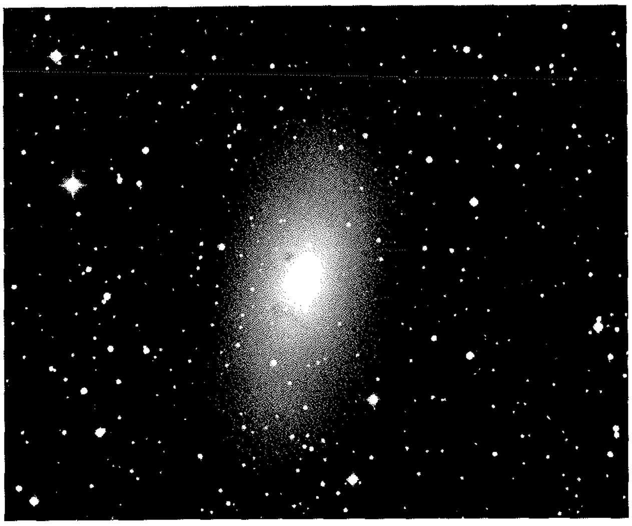
These photos from late 1991 and early 1992 illustrate some of the activities now under way at the future VLT site. 1. The building in Antofagasta in which the ESO VLT office is now located. 2. Here the ESO road to Paranal begins at the "Old Panamericana". 3. The VLT base camp at the foot of Paranal. 4. Geometric forms along the ESO road to Paranal. 5. Sr. Segovia of the FENIC blasting team holds a stick of high explosives with the detonating fuse in place. 6. A fraction of a second after the blast. 7. At the time of a blast, Paranal almost looks like a volcano . . . 8. Loading the debris on the lorry. 9. Dumping the debris on the leeside of Paranal. Photos by F. Bourlon (4, 5, 6, 7) and H. Zodet (1, 2, 3, 8, 9).







The Andromeda Galaxy



The fact that the astronomical objects on this and the preceding page lie in the northern celestial hemisphere should not worry our readers: please be assured that ESO continues to operate in the southern sky!

The southern part of the Andromeda Galaxy (M31) and one of its companions, the elliptical galaxy NGC 205, are here reproduced from one of the plates from the second major photographic survey, now in progress with the Palomar Oschin (Schmidt) Telescope. The original plates of POSS II are being copied in the photographic laboratories at the ESO Headquarters for the "Palomar Observatory/European Southern Observatory Photographic Atlas of the Northern Sky".

The photos shown here were masked and enhanced by ESO photographer Hans-Hermann Heyer. A comparison with the prints in the "Hubble Atlas" (1961; pp. 3 and 18) serves as illustration of the advances in astronomical photography during the past decades.

Note in particular the splendid resolution of M31 into individual stars and the dark dust lanes in NGC 205. North is up and east is to the left on both photos. *The editor*

Contracts Signed for Two VLT Instruments: FORS and CONICA*

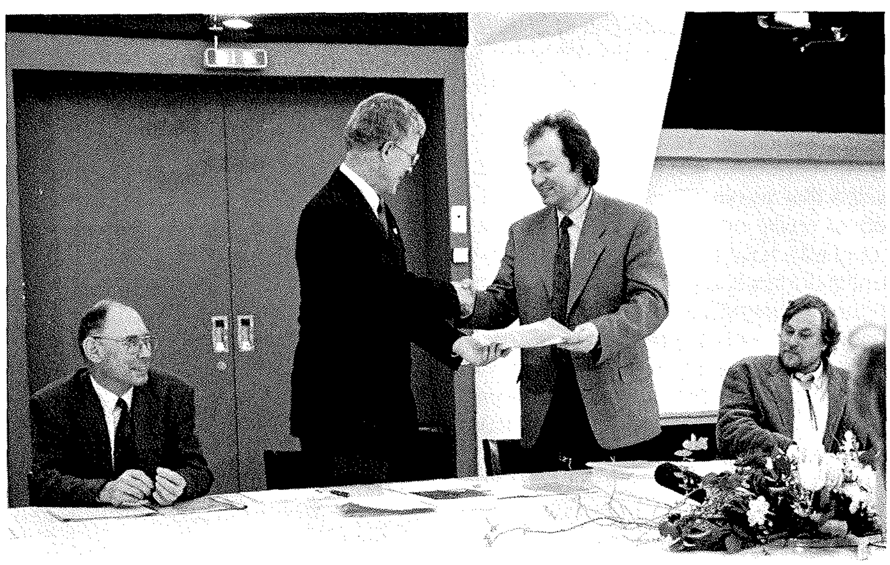
H. VAN DER LAAN, ESO Director General

Ladies and Gentlemen,

Welcome to this meeting room at the European Southern Observatory Headquarters; welcome especially to the teams of CONICA and FORS. This day and event mark a milestone on the trajectory of the VLT Observatory. It is something that many of us have looked forward to and worked towards.

It is also a milestone in ESO's history, and in its own way in the integration of European astronomy. I think we all know that throughout Europe there are astronomy groups and institutes, smaller ones and larger ones, who in part rely on ESO as an astronomy service organization. Throughout its almost 30-year history, ESO has provided science services for the community, primarily at the La Silla Observatory, but also in important ways here at ESO Headquarters by way of reduction services, measuring machines, computers, and also of bringing people together during Workshops and in Symposia. In fact this year we have a particularly busy Workshop and Symposium programme. The community has advised us primarily through committees such as the Users Committee, the Scientific Technical Committee, the Observing Programmes Committee, the astronomers in Council and through Panels and Working Groups.

I think the new element which is marked today is that henceforth the community will not only advise ESO, but will also work for and with ESO in a very substantial manner. The scope of the VLT programme is in a sense too large for this organization. It is not only the largest programme ever in ground-based astronomy, in relative terms, it's also much larger for ESO than, say, LEP was for CERN, or HERMES is for ESA. The people in our organization were almost entirely occupied by providing the



At the ceremony, from left to right: I. Appenzeller, H. van der Laan, R. Lenzen and R. Kudritzky.

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* Ed. note: This is a condensed version of a speech given on February 6, 1992, at a brief ceremony in the ESO Headquarters on the occasion of the official start-up on the work on two of the VLT instruments, FORS and CONICA, described in the following articles in this *Messenger* issue. On behalf of the FORS team participated Prof. I. Appenzeller (Landessternwarte Heidelberg), Principal Investigator, FORS team, Prof. K. Fricke (Universitäts-Sternwarte, Göttingen), Dr. H. Niklas, Dr. W. Seifert (Landessternwarte Heidelberg), Prof. W.-P. Kudritzki (Universitäts-Sternwarte München), Dr. Muschinok (Universitäts-Sternwarte München) and Dr. Kiesewetter (Universitäts-Sternwarte München).

The CONICA group was represented by Dr. R. Lenzen (Max-Planck-Institut für Astronomie, Heidelberg), Principal Investigator, Dr. S. Beckwith (Max-Planck-Institut für Astronomie, Heidelberg), Dr. K. Wagner, Dr. A. Eckert, Dr. R. Hofmann (Max-Planck-Institut für Extraterrestrische Physik, Garching), Dr. Roberto (Osservatorio Astronomico di Torino).

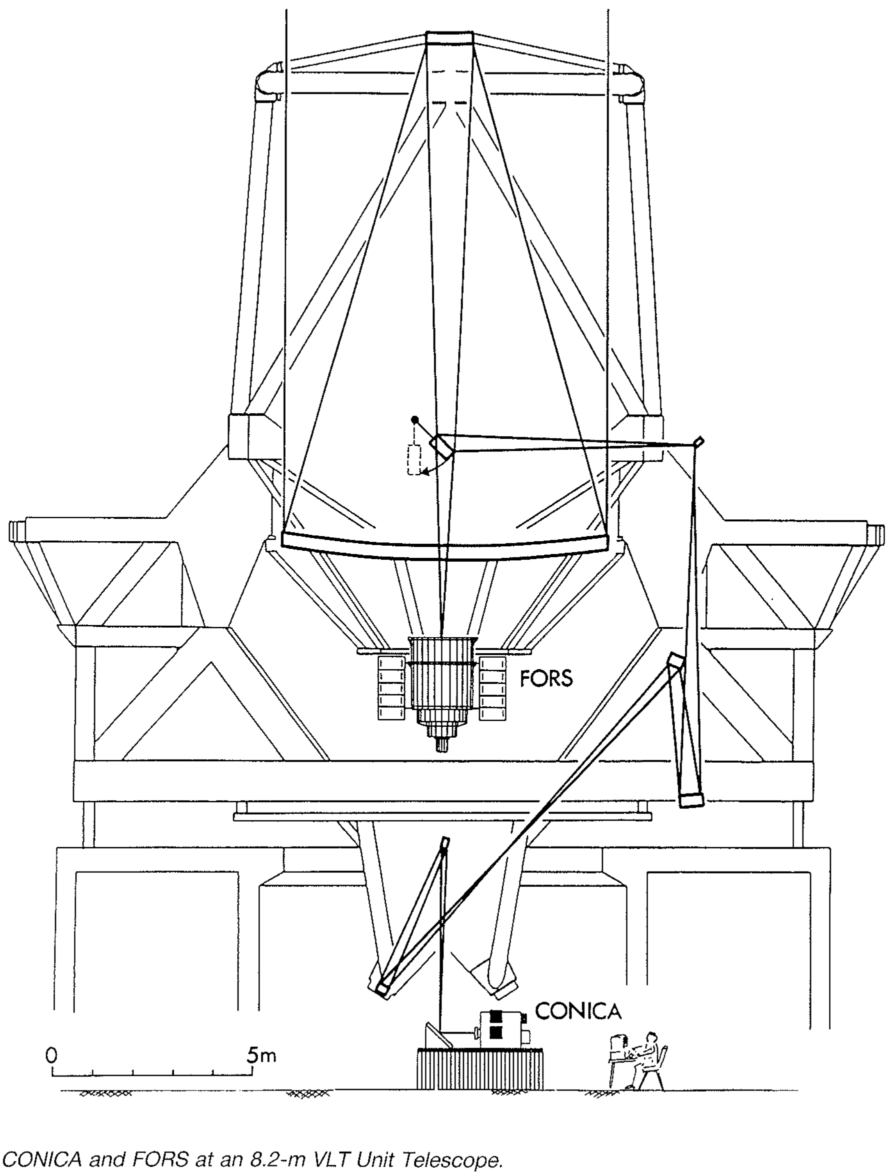
Present also were a number of ESO engineers and astronomers, who will be involved in the FORS and CONICA projects.

services that are expected from us and which are expected to be maintained and always be state-of-the-art, at La Silla and at Headquarters. It was with quite great difficulties that over the last four years we have been able to re-orient resources, so that now we devote about 60 person-years per year directly to the VLT programme.

In about 1984 and 1985, at which time I was myself a member of the STC, we started to discuss ways and means of mustering resources in our community for the VLT programme in more than advisory capacities. This community is largely university-based and they often have plenty of clever and ambitious people, but most universities also have a chronic shortage of money. Having worked in universities for decades my-self, I am well aware of this situation. And so the idea in the STC, ultimately blessed by Council, was that we would have an instrumentation programme for the VLT which would enable us to put together the many talents in the universities with the relatively few people at ESO, and with cash that comes from member states more easily to ESO than to the numerous universities throughout our member states. Especially in the last three years we have worked in-house in dialogue with the Working Groups and Committees to develop the VLT instrumentation plan. A policy had to be evolved with completely new features which differs from, say, ESA's well-known way of contracting focal-plane instruments for its satellites, but which also differs from our own tradition. I wish at this time to pay a particular tribute to four people who did a great deal of work in consultation with me to articulate this policy and to give it body and substance. They are Alan Moorwood, Head of the Infrared Instrumentation Group, Jacques Beckers, who was till recently Head of the High-Resolution and Interferometry Group, Sandro D'Odorico, who heads the Optical and UV Instrumentation, and Robert Fischer who did so much in the Contracts Department. Especially Sandro, who coordinated this whole effort, did a masterful job of finally articulating it, so that we could also have it approved by our governing bodies and gain wide acceptance in the community.

After this policy was articulated and approved, there followed the Call for Proposals for the first round. There were the information meetings, the responses and the assessments which brought the conclusions leading to this meeting today that the first two external instruments will both be built in Germany and, in fact, both with Principal Investigators (PIs) in Heidelberg. In our organization we have an esprit de juste retour. We try to distribute work, contracts and many other things that our organization does equitably over the member states. We are also subject to peer review, subject to financial rules and that in the short term always leads to bunching and to non-even distribution. It's only in the long term and in retrospect and integrated over many services, many aspects of our activities that the equitability is actually attained. It can be demonstratet that the intention works if you convolve events over a large enough area of both time and character. It's now my time to congratulate the two teams on winning these Europe-wide competitions. You have demonstrated that you have ideas, talents and capacities which are world-class and which give us confidence that your goals will be achieved.

The contracts were less simple than one might have expected. The new policy after all was implemented for the first time and needed many iterations before it converged to a result that could receive signatures from both sides. For CONICA it was somewhat easier than for FORS. Nevertheless, it took practically the same amount of time. Perhaps we put less pressure on it as we were so concerned to also complete the FORS contract and that's why we can celebrate this event for both teams on the same day and really start the work. The FORS contract was complicated by the legal realities of the new Germany and by the fact that this is a federated nation with very strong competences of the Länder, so that if you make a contract with three or four institutes you have to deal not only with these universities, with the institutes, with the faculties, with the Rectors of the universities, but also with the Ministries of Education, possibly with the Ministries of Finance of these Länder and the whole thing becomes interestingly complicated. To solve such a puzzle takes time and good will, and I want to thank all of you who worked to achieve the result which is on the table today. We wish you all in the coming years a lot of pleasure in design-



CONICA and FORS at an 8.2-m VLT Unit Telescope.

ing and constructing these instruments.

I have no illusion that we will not have problems. We will run into technical, financial or schedule problems, we might even run into some contractual problems, but that is not a serious worry. There is enough talent and enough good will on both sides to solve the problems as they arise. At the end of this phase of design and construction, there is the commissioning of the instruments when both your teams will be rewarded, not only with doing the challenging work, but also with the opportunity to carry out very major science programmes. With your instruments on 8-m telescopes on Cerro Paranal, you will enter wholly new domains of parameter space which will no doubt lead to spectacular results and interesting discoveries.

I close by reiterating the satisfaction in our organization of having attained these contracts, of expressing our confidence in the talents and abilities of the teams and of anticipating with pleasure our collaboration in the many years to come until we meet on Cerro Paranal to commission these beautiful devices to explore the southern sky.

Coudé Near Infrared Camera Instrument Contract Signed

R. LENZEN, Max-Planck-Institut für Astronomie, and O. VON DER LÜHE, ESO

The Coudé Near-Infrared Camera (CONICA) will be one of the first instruments to be constructed outside ESO for the Very Large Telescope (see the review article on VLT instruments in *The Messenger*, **65**, pp. 10–13). A contract for the construction of CONICA has been signed by ESO and a Consortium headed by the Max-Planck-Institut für Astronomie (MPIA, Heidelberg), with the Max-Planck-Institut für Extraterrestrische Physik (MPIE, Garching) and the Osservatorio Astronomico di Torino (OATo, Turin) as partners. The signature of this contract is the first step implementing a policy of active ESO community participation in instrument development. Equipping four large telescopes with four foci each is clearly beyond the capability of ESO, and the success of the VLT will depend significantly on the ability of the astronomy community in Europe to build state-of-the-art instrumentation.

CONICA is the instrument which is labelled High-Resolution Near-Infrared Camera in the VLT Instrumentation Plan. It will be located at the coudé focus of the first unit telescope, where it will provide diffraction-limited images, and do polarimetry and low resolution spectroscopy. The instrument will cover the 1 μm to 5 μm wavelength region. Where possible, it will use directly the diffraction-limited images provided by the VLT adaptive optics system. Speckle imaging methods, image selection, and methods combining partial adaptive optics or rapid guiding with image selection and interferometric imaging can be used when the adaptive optics system does not produce a diffraction-limited focus. Spectral resolution will be achieved with about 40 broad-band and narrow-band filters, as well as with a selection of grisms which provide a spectral resolution between 500 and 1000 throughout the wavelength range. Polarimetry can be done using a set of wiregrid analysers and two Wollaston prisms. Scientific programmes which will be pursued with CONICA include studies of outflows and disks of young stellar objects, search for low mass companions of nearby stars, imaging of envelopes around red giants, studies of the galactic centre, the energetics of Seyfert galaxies and quasars, and highly resolved images of radio jets and hot spots.

Figure 1 shows the optical concept of CONICA. The telescope light beam passes a tunable atmospheric dispersion compensator (TADC) before entering the camera proper. The TADC is removable, and is needed only for broad-band imaging at shorter wavelengths. The entrance window (EW) seals the cyrostat, which maintains the cold optics at a temperature of about 70°K, and accepts a field with 90 mm (45 arcsec) in diameter. Cooling of the cryostat is provided by a closed-cycle cooler. The focal plane assembly (FPA), located at the coudé focus, consists of two wheels that carry sets of field-of-view masks, slits, coronagraphic stops, mirrors, and test targets. The light which is reflected from the telescope-oriented faces of the various focal plane stops is used to feed a visible field-viewing camera which guarantees proper pointing of the instrument.

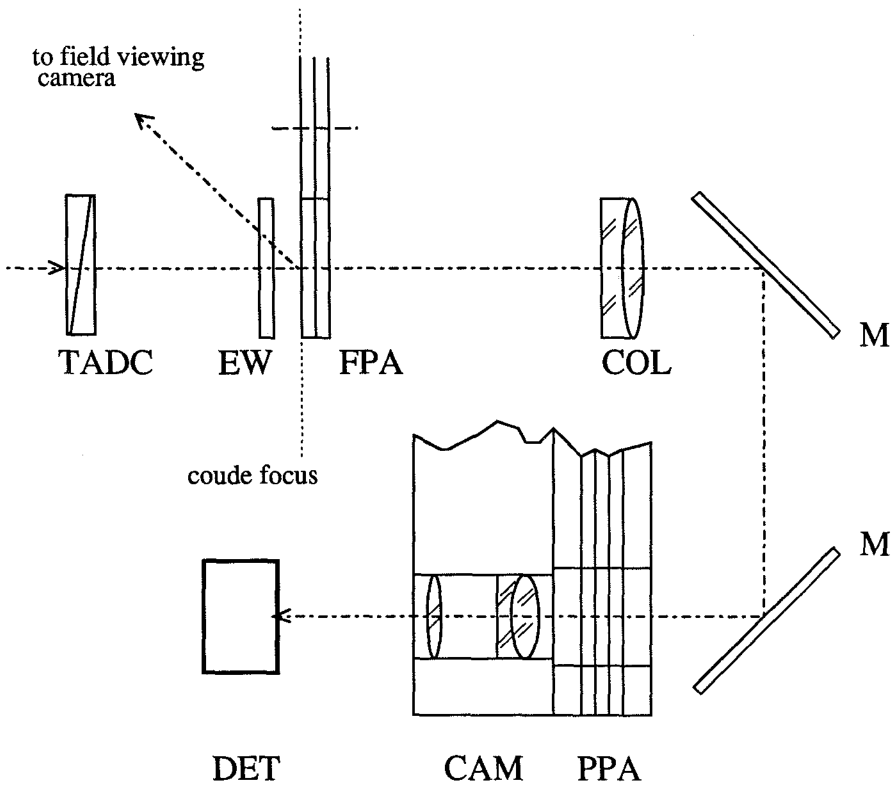


Figure 1: *A schematic of the CONICA optical layout.*

A collimator (COL) lens generates a parallel beam and produces a pupil image near the pupil plane assembly (PPA). The collimator will be used for the entire wavelength range covered by CONICA. Two mirrors fold the light path, which result in a compact cryostat. The pupil plane assembly consists of five wheels carrying a selection of Lyót stops, filters, grisms, and polarization analysers. An additional wheel carries camera lenses (CAM) which provide a selection of five magnifications in order to use efficiently the accepted field of view and the angular resolution throughout the 1 μm . . . 5 μm range. There will be two sets of camera lenses, optimized in optical performance and throughput for the 1 μm . . . 2 μm and the 2 μm . . . 5 μm spectral ranges.

Two 256×256 pixel detectors (DET), cooled to their optimum operation temperature between 20°K and 70°K, will be included in the camera in order to cover the wavelength range efficiently. A SBRC InSb detector is foreseen to be used mainly for the long wavelength region, a Rockwell NICMOS 3 HgCdTe detector is baselined for direct imaging and speckle applications at short wavelengths. Detectors are selected by rotating the folding mirror assembly; it will not be possible to observe with both detectors simultaneously. The field subtended by a detector will range from 3 arcsec for diffraction-limited resolution at 1 μm to 33 arcsec for full field viewing. The optical design of the camera is such that CONICA can be upgraded with larger (512×512 pixels) detectors as soon as these become available.

The optics, mechanics and cryogenics, as well as the control electronics will be constructed by MPIA, who also host the principal investigator of the project. The detector electronics will be built jointly by MPIE and OATo. MPIE will also supply the data analysis software and a cold fast shutter unit. CONICA is scheduled for commissioning at the VLT in December 1997.

FORS – The Focal Reducer for the VLT

I. APPENZELLER, Landessternwarte Heidelberg, Germany, and
G. RUPPRECHT, ESO

Introduction

On February 6, 1992 at the ESO Headquarters in Garching the FORS instrument project for the ESO Very Large Telescope was publicly started with a kickoff meeting. FORS, the FOcal Reducer/low dispersion Spectrograph, will be the first instrument built outside ESO to be installed at the VLT observatory.

The idea for a set of general-purpose focal reducers for the VLT can be traced back to the recommendations of the ESO Working Group on Imaging and Low-Resolution Spectroscopy, published in VLT Report No. 52 (1986).

The experience gained with EFOSC-type instruments at the 3.6-m telescope and at the NTT then led ESO to propose in the VLT Instrumentation Plan of June 1989 the construction of two dioptric focal reducer/low dispersion spectrographs for deep-imaging, low-resolution and multi-object spectroscopy. The Cassegrain foci were chosen for the instruments because of their high throughput, to minimize the amount of scattered light and to make them suitable for polarimetric observations.

Following a Call for Proposals issued in 1990 a consortium composed of three German astronomical institutes (the Landessternwarte in Heidelberg and the University Observatories of Göttingen and München) was chosen in 1991 for the realization of the project.

The Plan

It is expected that the demand for observing time with a focal reducer at the VLT will be comparable to or larger than on the existing large ESO telescopes. FORS I and II will therefore be something like the workhorses of the VLT, and their duplication will save construction costs and later simplify operation and maintenance. The two identical instruments will be installed on Unit Telescopes 1 and 3 in 1996 and 1998, respectively.

Their basic observing modes will be
(1) direct imaging,
(2) low-dispersion grism spectroscopy,
(3) multi-object spectroscopy,
(4) polarimetry.

These modes can be combined e.g. to allow imaging polarimetry or spectropolarimetry.

The instruments are specified to work over the wide wavelength range 330 to 1100 nm. Their efficiency (excluding the detector) should be better than 50% at wavelengths greater than 350 nm and peak near 450 nm with approximately 78%. The detector will probably be a large CCD with 2048 × 2048 pixels and a 24 μm pixel size.

The Implementation

The fundamental parameters of the optical design are the image scale at the VLT Cassegrain focus, which is 528 μm/arcsec, and the intended final image on the detector. Combining the expected image quality of the VLT telescopes with the pixel size of available large CCDs, a scale of 0.2″/pixel was specified for the standard observing mode.

In order to obtain a large field of view and to allow accurate polarimetry, an all-dioptric design was chosen. Its principal layout was derived by ESO optician B. Delabre on the basis of the experience gained with EFOSC.

Figure 1 gives the optical paths of the light passing from three different positions in the focal plane of the telescope (situated to the left of Figure 1) to CCD detector (on the right). The first group of lenses (the collimator) produces a parallel beam and also forms an image of the telescope's entrance pupil (i.e. of the main mirror). The second group of lenses (the camera) then focuses the parallel beam onto the CCD detector, thus re-imaging the large image in the telescope focal plane on a smaller scale in the detector plane. The standard "wide-angle" collimator will have a focal length f of 1230 mm and a collimated beam diameter of 90 mm. During periods of excellent seeing it will be possible to double the image scale by exchanging the standard collimator by a second, high-resolution collimator (f = 615 mm, collimated beam diameter 45 mm) using a remotely controlled internal exchange mechanism.

The parallel beam section is tightly filled with various optical components. There are rotatable phase retarder plates and a Wollaston prism for polarimetric observations, grism, and broad-band colour filters. All these components can be moved in and out of the beam by means of rotating wheels or a swing arm. The grism presently

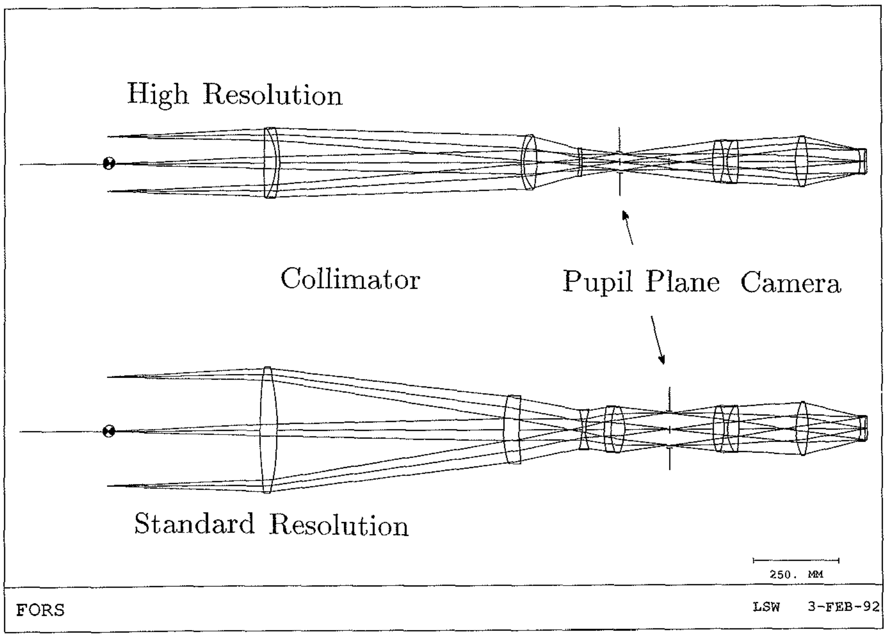


Figure 1: *Schematic drawing of the optical layout of the focal reducers showing the standard (bottom) and high-resolution (top) configurations. Since the camera sections are identical, the changeover will be accomplished by an exchange of the collimators.*

foreseen will allow spectroscopy with resolutions up to ≈ 2000.

The camera has a fixed focal length of 280 mm. It includes the focusing mechanism and two additional wheels for interference filters. (Note that in order to avoid position-dependent differences of the filter band pass over the image, interference filters have to be inserted outside the parallel beam.) When the standard collimator is used, the final focal ratio is 3.1; with the high-resolution collimator this changes to 6.2 and the image scale accordingly becomes 0.1″/pixel. The available field of view in the two modes will be 6.8′ × 6.8′ (square) and (at least) 2′ diameter (circular), respectively.

To get an impression about the dimensions of the optics involved in FORS one should notice that the standard collimator field lens is 36 cm in diameter and therefore of a similar size as the objective of what would have been a medium-sized refracting telescope at an observatory 100 years ago!

Mechanically, the instrument will consist of three main units. The first one contains the multi-object spectroscopy unit, described below in more detail. The second one houses the collimators and carries the instrument control electronics, and the third one contains the optics in the collimated beam and the camera. The detector cryostat will be fixed to the camera unit. The whole instrument will be attached to the Cassegrain focus rotator by means of its top flange.

Without the electronics racks (the sizes of which have not yet been finally determined) each FORS will have a diameter of about 1.7 m and a length of approximately 2.5 m. This does not include the detector cryostat which will be delivered by ESO. The weight of the whole instrument will be about 2 tons.

Figure 2 shows schematically the outside appearance of the instrument. Figure 3 is a cut through the instrument indicating the location of its major components.

Of fundamental importance for the performance of the instrument is a minimization of the image motion resulting from mechanical flexure during extended integration times, when the gravity vector changes with respect to the instrument axis. To suppress this effect the housing of FORS has been designed in such a way that the effect of the movement of the collimator is exactly compensated by the flexure related movement of the camera. Computer simulations show that as a result of this flexure compensation it will be possible to keep image shifts well below 1/4 of a pixel even during exposures of several hours duration.

One of the crucial components of the instrument is the multi-object spectroscopy (MOS) unit, located in the focal plane common to the telescope and the instrument. It will consist of 19 pairs of slitlets, each of them individually driven by a motor and controlled by a highly precise position encoder. This device will allow simultaneous spectroscopy of up to 19 objects, distributed over the field of view. The projected slit length on the sky will be 22.5″. By aligning the slitlets properly, it will also be possible to form a long slit of arbitrary width. Finally, by alternatively opening and

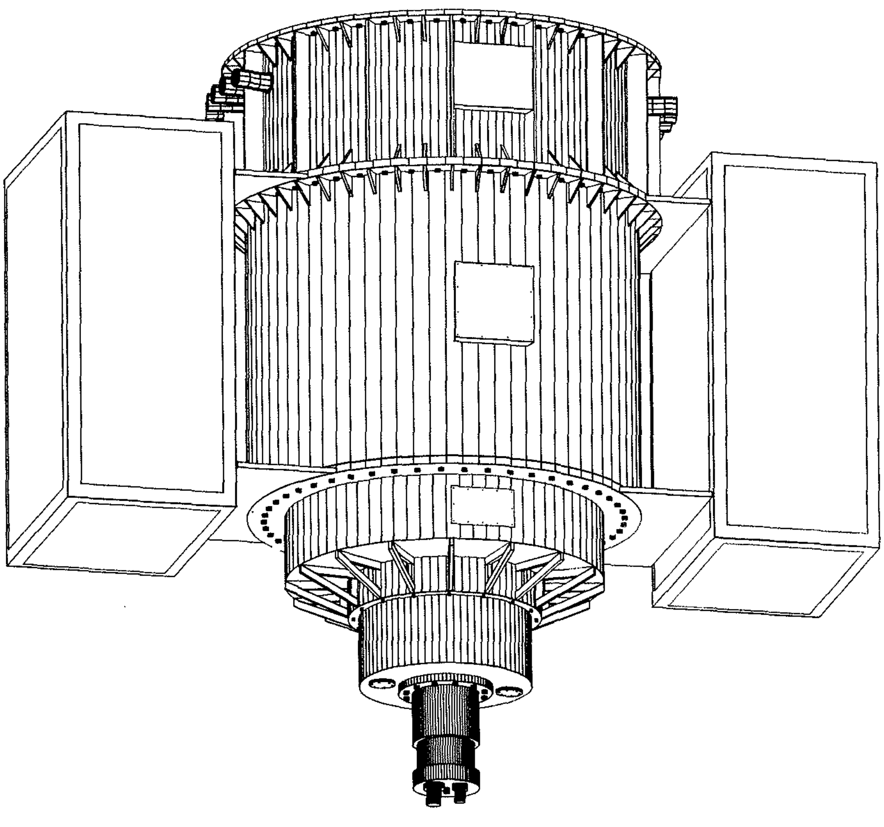


Figure 2: *CAD drawing of an outside view of the finished instrument.*

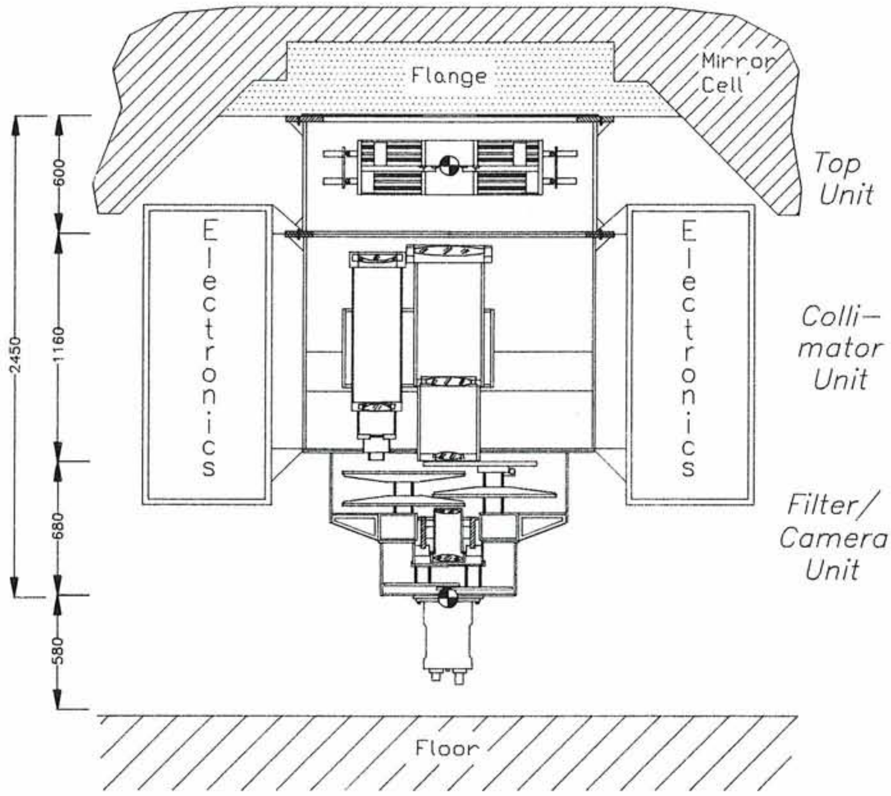


Figure 3: *Cut through the instrument including its major sub-units (MOS unit in the focal plane, the exchangeable collimators, collimated beam space with the components mentioned in the text, and the camera.*

closing adjacent slitlets completely, a focal plane mask for differential imaging polarimetry of extended objects can be produced.

Figure 4 shows a prototype of the slitlets. This prototype has been built to test critical properties of the slitlets like their sensitivity to flexure, guiding precision and positioning accuracy. The basic components visible here are the slitlet arm that will carry the polished slit blade (top right), the DC motor (left), the two linear ball bearings and the high precision spindle drive (centre), and the linear position encoder (bottom). This and similar setups are also used to test the electromechanical accuracy, the drive controls and the long term reliability of these devices.

The approach chosen here for the MOS unit illustrates the emphasis on maximal operational flexibility common to all functions of the instrument. It will be possible to switch between different instrument setups in a matter of seconds. Changing from spectroscopy to imaging or vice versa, e.g., is accomplished in less then 15 seconds by moving all slitlets simultaneously. Changing filters, grisms or Wollaston prisms is done by rotating the appropriate wheels, and the switch between the high and standard resolution collimators or the insertion of the retarder plates for polarimetry will also take a few seconds only.

As specified for all VLT instruments, the focal reducers will be designed for fully remotely controlled operation. All functions are motorized, and numerous safety features are included.

Building the two copies of FORS in the relatively short time dictated by the progress of the VLT project requires a major manpower effort at the three participating institutes. According to the present estimates, about 150 man-years will be needed to complete the two instruments. Among the key persons presently involved in the project are K. Fricke and R.-P. Kudritzki, who head, respectively, the Göttingen and München task groups of the three-institute consortium. I. Appenzeller of the Landessternwarte Heidelberg is the Principal Investigator of this project. All optical design and development work is being carried out in Heidelberg under the responsibility of R. Östreicher and W. Seifert. H. Nicklas, K.-H. Duensing, S. Gong, and R. Harke of the Göttingen observatory lead the complex effort of designing and producing the sophisticated mechanical system of the instruments. B. Muschielok, H. Geus, H.J. Hess, and S. Kiesewetter at the University Observatory of München are responsible for developing the electronic system and the instrument related software, while O. Stahl and S. Möhler are designing the science support software at the LSW Heidelberg. A particularly important member of the team is also H. Böhnhardt who will be in charge of managing the whole cooperative effort from his office at the USW München.

Scientific Opportunities

The use of the FORS instruments on the 8-m VLT unit telescopes, located at one of the astronomically best places on earth promises outstanding new results in many different fields. Based on the anticipated transmission of the instrument, the efficiency of the detector and the quality of the atmosphere on Cerro Paranal, we have calculated that it will be possible to detect – in imaging mode – objects fainter than 30^m with integration times of the order of an hour.

Among the exciting new possibilities of the new instruments will be the quantitative spectroscopy of individual early-type stars up to distances of about 4 Mpc, i.e. well outside our local group. Primary distance indicators such as δ Cephei stars and Planetary Nebulae will become observable to unpre-

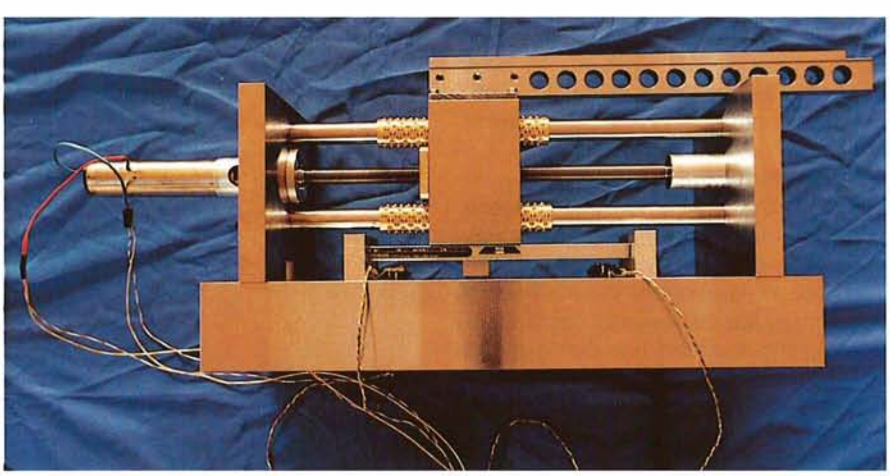


Figure 4: *Prototype of a single slitlet for the MOS unit. The whole assembly is about 35 cm long, the slitlet arm can be extended another 25 cm. See text for details.*

cedented distances, promising real progress in clarifying the extragalactic distance scale. As an example we note that Planetary Nebulae should be observable with FORS not only in the Virgo and Centaurus clusters but also at the distance of the "Great Attractor" region of enhanced galaxy densities.

The FORSes will also be excellent instruments for spectroscopic surveys of (field) galaxies down to B-magnitudes fainter than 24^m. They will serve to constrain the basic cosmological parameters and the scenarios for the evolution of galaxies as well as to investigate the clustering of galaxies in redshift.

With their superb imaging capabilities the FORSes will be particularly valuable for investigating the galaxy environment of QSOs, for probing the large-scale structure of the distant universe in selected fields and, perhaps, for finding very young or still forming galaxies.

Finally we note that in astronomy new and more powerful instruments almost always resulted in the discovery of new and often completely unexpected types of objects. Not the least for this reason are we looking forward with great excitement to the year 1996 when, if everything goes well, FORS I will see its first light at the VLT on Paranal.

Delay Lines of the VLT Interferometer: Current Status

M. FAUCHERRE and B. KOEHLER, ESO

The four 8-m telescopes of the VLT, located at fixed positions, as well as the movable auxiliary telescopes, need delay lines between them to cancel out the optical path difference (OPD) due to sidereal motion. The ESO design comprises 60 metre delay lines using cat's eye optics of 80 cm diameter to transmit an 8 arcsec field-of-view.

An exceptionally high dimensional stability is required both for longitudinal and lateral positioning. A feasibility study was performed by MBB (Ottobrunn) between October 1990 and September 1991 to find solutions for both requirements. The goal was to reach the requirements with a straightforward single-stage approach based on state-of-the-art air bearings (passive solution) or magnetic suspension (active solution).

Six commercially available air bearings were found to be inadequate due to excessive acoustic noise exciting cat's eye eigenmodes. The magnetic suspension option is an elegant solution to actively control vibrations. However, to eliminate uncertainty with regard to stability performance, a prototype is needed to assess the performance at the unusual manometer level.

Following this, tests were performed by ESO and OCA in September 1991 in Limoges (Ateliers Maître, Microcontrôle) and in October 1991 at the TU München on air bearings using different technologies. The test carried out at the TU München on sintered bronze air pads, patented by Prof. Heinzl's group, revealed a level of acoustic noise more than an order of magnitude lower than air bearings previously measured. This shows that air bearings exist which meet our OPD requirement, and that air bearings are still potential candidates for VLTI delay lines.

In conclusion, the main driver to select a solution for VLTI delay lines remains the cost for the design, manufacturing and installation on the site.

References

Jörck, H., Maurer, R., Käse, J., Faucherre, M., Beckers, J.M., Kühn, G. and Hupe, H., "The design of delay lines for the VLT Interferometer", Proc. ESO Conf. on "High Resolution Imaging by Interferometry", Garching, March 1992.

Faucherre, M. and Maurer, R., "On metrology systems for delay lines", Proc. ESO Conf. on "High Resolution Imaging by Interferometry", Garching, March 1992.

Bourlon, P., Faucherre, M. and Koehler, B., "Report on experimental vibration measurements on air bearing pads at Technische Universität München", internal document, issue December 1991.

IRAC 2 – ESO's New Large Format Infrared Array Camera

IRAC 2 has been developed to exploit the new generation of large array detectors for broad and narrow band infrared imaging and to gain experience with these devices of relevance for the VLT. It is equipped with a Rockwell 256×256 pixel Hg:Cd:Te NICMOS 3 array; broad and narrow band filters between 1 and 2.5 μm; a scanning Fabry Perot etalon covering the range ~ 2–2.5 μm at R ~1000 and five selectable objectives providing for image scales from 0.15 to 1.1 arcsec/pixel (at the 2.2-m telescope). At present IRAC 2 is in the integration and test phase in Garching with installation and tests on the ESO/MPIA 2.2-m telescope scheduled for May 1992. An HP workstation will be used for instrument control, with MIDAS available on-line for image display/handling, in line with the current ESO policy of phasing out the HP 1000 computers on La Silla. The final user interface and control software as well as new VME based motor controllers are being developed on La Silla and are planned to be installed in October 1992. In the meantime, the instrument will be used with software developed in Garching for laboratory testing. The accompanying photographs show the instrument mounted on the telescope simulator in Garching and the cryogenically cooled optical assembly.

Observational Capabilities

IRAC 2 will be installed initially at the 2.2-m telescope where it will be mounted on the F/35 infrared adapter. Its main characteristics are summarized in Table 1. It should be noted that the five objectives have been provided not only to allow optimization of the image scale for particular scientific programmes and seeing conditions but also to foresee use of this camera with different array detectors and possibly at the 3.6-m telescope in future. For most applications and average seeing conditions it is expected that the 0.53 and 0.28″/pixel scales will be the most ap-

Figure 1: *IRAC 2 mounted on the telescope simulator during testing in Garching.*

propriate. The higher magnifications yield a somewhat larger but circular field limited to 3′ by the cryostat window which also acts as the field lens. The K' filter has been kindly supplied by Dr. R. Wainscoat at the University of Hawaii. It is slightly narrower and shifted to shorter wavelengths compared with the standard K filter in order to reduce the telescope/sky thermal background in this band. The narrow band filters are intended for imaging in prominent spectral features. In the K band they provide almost complete coverage from 2.04 μm to 2.4 μm (allowing for e.g. observations of He I, H_2 and Brγ in low redshift galaxies) and can be used alone or as order isolating filters for the Fabry Perot.

Table 1: *IRAC 2 Characteristics*

Image Scales and Fields		
Objective	arcsec/pix	arcsec
A	0.15	38×38
B	0.28	72×72
C	0.53	136×136
D	0.74	Φ = 180
E	1.1	Φ = 180
Filters		
Name	λ (μm)	Δλ (μm)
J	1.25	0.3
H	1.65	0.3
K'	2.1	0.34
K	2.2	0.4
NB1 ([FeII])	1.262	0.04
NB2 ([FeII])	1.645	0.04
NB3 (HeI)	2.058	0.036
NB4	2.105	0.037
NB5 (H_2)	2.121	0.039
NB6	2.136	0.038
NB7	2.148	0.037
NB8 (Brγ)	2.164	0.037
NB9	2.177	0.038
NB10	2.216	0.075
NB11 (CO)	2.365	0.088
Fabry Perot	~ 2–2.5	λ/Δλ~1000
Array Detector		
Type	Rockwell NICMOS 3 (Hg:CD:Te)	
Format/pitch	256×256	40 μm
Bad pixels	416 (0.6 %)	

Performance

The NICMOS 3 engineering array measured in our test cryostat has a quantum efficiency increasing from ~ 0.4 in the J band to ~ 0.6 at K; a read noise of ~ 40e/s and a dark current of ~ 15e/s (although most of this may be radiation from the on-chip amplifier). Its sister science grade array appears to exhibit comparable quantum efficiency and read noise but is of far superior cosmetic quality with a relatively small number of unuseable pixels (~0.6 %) for devices of this type. Due to time pressure, this array was installed directly in the camera for system testing including measurements of the optical quality, so has not yet been characterized as well as the engineering array. With regard to its astronomical performance, however, its exact read noise and dark current values are not particularly relevant at the sky background levels expected with IRAC 2.

Sky backgrounds measured with IRAC 1 at the 2.2-m telescope are J ~ 14.5, H ~ 13.8 and K ~ 12.1 mag/arcsec^2 and the overall system efficiency with IRAC 2 is expected to be ~ 30 %.

Under these conditions, the background limited performance (3σ in 1 minute) should correspond to J~ 20.2, H~19.3, K~18.2 and K'~18.7 mag/arcsec^2. Corresponding values (3σ in 1 minute) for photometry in a 5″ software aperture are J ~ 18.4, H ~ 17.7, K ~ 16.7 and K′ ~ 17.2. Based on the experience gained with other infrared cameras it is expected that the ultimate deep imaging limits achievable with longer measurement times will be flat field limited at ~ 10 mag. below the sky.

Availability to Visiting Astronomers

As it is expected that IRAC 2 will offer a performance which is competitive or superior to other infrared cameras existing elsewhere, we would like visiting astronomers to have access to it as soon as possible. Proposals are therefore invited for the use of IRAC 2 at the 2.2-m telescope in period 50 (October 1992–March 1993) by the usual deadline of April 15, 1992.

Unfortunately, as this deadline falls before the first telescope test, proposers will obviously have to accept some shared risk. As the results of this test will be known before the OPC meeting in June, however, it will be possible to take both these and the overall instrument/software status into account before the final time allocations and schedule are made. It is recommended that Proposers (i) place as few restrictions as possible on the required observing dates and (ii) also state in the section "Special Remarks" whether or not their programme is also feasible using the 64×64 IRAC 1 camera already installed at the 2.2-m.

A. MOORWOOD and G. FINGER
ESO-Garching, Feb. 1992

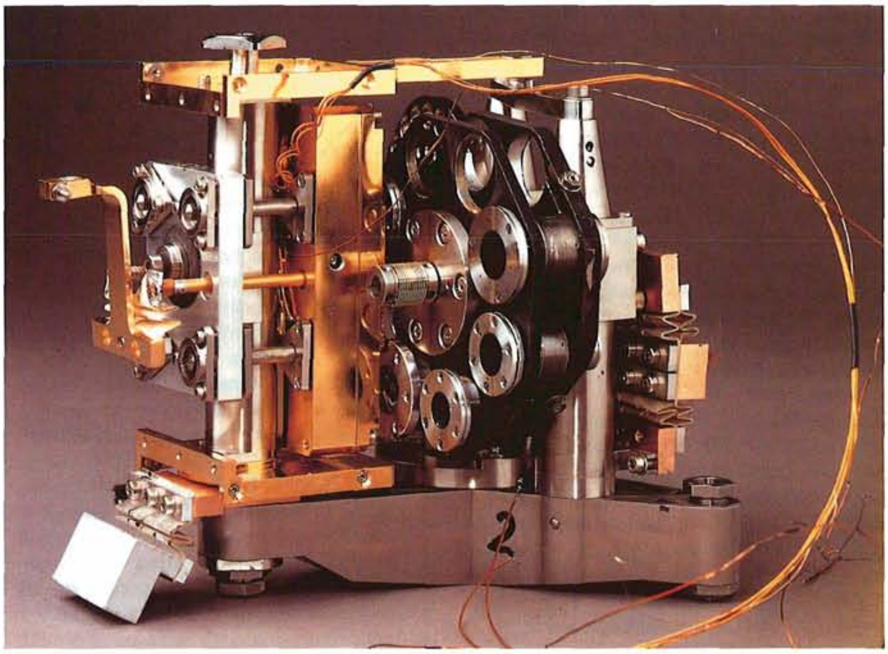


Figure 2: *The cryogenically cooled optical assembly showing the array detector mount (gold), objective wheel and, just visible behind the latter, the 24-position filter wheel.*

Visiting Astronomers

(April 1 – October 1, 1992)

Observing time has now been allocated for Period 49 (April 1 – October 1, 1992). The demand for telescope time was again much greater than the time actually available.

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

3.6-m Telescope

April 1992: Reimers/Köster, Shaver/Böhringer/Ebeling, Miley et al. (2-001-43K), François, Pallavicini/Pasquini/Randich, Hensberge et al. (5-005-45K), De Graauw et al. (9-003-49K), Zamorani/Vettolani/Bardelli/Zucca/Scaramella/MacGillivray/Collins, Jørgensen/Rasmussen/Franx, Van Drom/Hutsemékers.

May 1992: Van Drom/Hutsemékers, Turatto et al. (4-004-45K), Cacciari/Clementini, Danzinger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Van der Hucht/Thé/Williams, Weitzel/Leinert, Mirabel/Duc/Dottori, Böhringer et al. (1-023-49K), Amram/Balkowski/Le Coarer/Marcelin/Sullivan/Cayatte.

June 1992: Corradi/Schwarz/Boulesteix, Bandiera/Corradi/Boulesteix, Mathys, Da Silva/de la Reza, Pasquini/Spite M./Spite E./Lindgren H., Lagrange-Henri/Loinard/Bouvier/Gomez/Bertout, Baade/Crane, Ferlet/Lemoine/Vidal-Madjar/Dennefeld, Vladilo/Centurion/Molaro/Monai, Schmid/Schild.

July 1992: Duerbeck/Leibowitz/Shara, Turatto et al. (4-004-45K), Duerbeck/Leibowitz/Shara, Moehler/de Boer/Heber, Jockers/Boehnhardt/Thomas/Kiselev, test of TIMMI (Moorwood), reserved – "WAD", Caulet/Hook/Pirenne/Brown/Waller/Woodgate, Danziger/Gilmozzi/Zimmermann/Hasinger/MacGillivray.

August 1992: Danziger/Gilmozzi/Zimmermann/Hasinger/MacGillivray, Ruiz/Leggett/Bergeron, P., Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Macchetto/Sparks, Macchetto/Sparks, Barbon/Marziani/Notni/Radovich/Rafanelli/Schulz, Freudling.

September 1992: Turatto et al. (4-004-45K), Reimers et al. (2-009-45K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Vettolani et al. (1-019-47K), Mazure/Rhee et al. (1-014/005-43K), Danziger et al. (6-003-45K).

3.5-m NTT

April 1992: Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette, Bender et al. (1-004-43K), Turatto et al. (4-004-45K), De Graauw et al. (9-003-49K), Boisson/Joly/Kotilainen/Ward/Moorwood/Oliva, Cox/Baluteau/Emery/Gry, Meylan/Djorgovski/Thompson, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Thomsen/Hjorth/Grundahl Jensen/Sodemann.

May 1992: Surdej et al. (2-003-43K), Miley et al. (2-001-43K), Webb/Shaver/Carswell/Barcons/Rauch, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Le Bertre/Lequeux, Krautter/Evans/Weight/Rawlings, Fosbury/Morganti/Robinson/Hook/Tsvetanov, Zinnecker/Reipurth/Brandner, Bandiera, Fosbury/Morganti/Robinson/Hook/Tsvetanov, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette, Zeilinger/Bertola/Bertin/Danziger/Dejonghe/Pizella/Sadler/Saglia/Stiavelli/de Zeeuw.

June 1992: Zeilinger/Bertola/Bertin/Danziger/Dejonghe/Pizella/Sadler/Saglia/Stiavelli/de Zeeuw, Buonanno/Matteucci/Fusi/Pecci/Danziger, Cimatti/di Serego Alighieri, Rampazzo/Bland-Hawthorn/Hernquist/Blandford, Lutz/Genzel/Drapatz/Krabbe/Harris/Hillier/Kudritzki, Richtler/Wagner/Held/Capaccioli, Surdej et al. (2-003-43K).

July 1992: Augusteijn/van der Klis/van Kerkwijk/van Paradijs, Capaccioli/Piotto/Zaggia/Stiavelli, Piotto/Cacciari/Ferraro/Fusi Pecci/Djorgovski, Carollo/Danziger, Danziger/Carollo, Capaccioli/Böhm/Lorenz/Richter, Falomo/Tanzi.

August 1992: Falomo/Tanzi, Walsh/Meaburn, Alcaino/Liller/Wenderoth, Eckart/Genzel/Hofmann/Drapatz/Sams, Stecklum/Eckart/Hofmann/Henning, Hofmann/Eckart/Drapatz/Genzel/Sams, Redfern/Pedersen/Cullum/Charles/Callanan/Shearer, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Christensen/Sommer-Larsen/Hawkins/Flynn, Bowen/Lanzetta, Cetty-Véron.

September 1992: Lagerkvist/Williams/Magnusson/Fitzimmons/Dahlgren, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Moorwood/Origlia/Oliva, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, De Lapparent et al. (1-003-43K), Surdej et al. (2-003-43K), Peterson/D'Odorico/Tarenghi/Wampler/Yoshii/Silk.

2.2-m Telescope

April 1992: Miley et al. (2-001-43K), Bender et al. (1-004-43K), Pagel/Terlevich/Diaz/Vilchez/Edmunds, Turatto et al. (4-004-45K), Danziger/Buonanno/Fusi Pecci/Matteucci/Carollo, MPI time.

May 1992: MPI time, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Prusti/Whittet/Chiar/Smith, Van der Hucht/Thé/Williams, Menard, Oosterloo/Prieur, Allard/Köster/Vauclair.

June 1992: Kunkel/Zinnecker/Schmitt, Turatto et al. (4-004-45K), Waelkens/Hu/van Winckel, Waelkens/Hu/van Winckel, Guarnieri/Barbuy/Bica/Ferraro/Fusi Pecci/Ortolani, De Winter/Thé, Mirabel/Lagage/Cesarsky C., Pottasch S.R./van de Steene/Sahu K.C., Surdej at al. (2-003-43K), Richtler/Grebel/Kaluzny, Grebel/Richtler.

July 1992: Rosa/Kinkel, Bertola/Rix/Zeilinger/Noziglia, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Sicardy/Barucci/Brahic/Ferrari/Roques, Habing et al. (5-007-45K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Sabbadin/Cappellaro/Turatto/Benetti/Salvadori, Azzopardi/Lequeux/Rebeirot, Turatto et al. (4-004-45K).

August 1992: Turatto et al. (4-004-45K), Arnaboldi/Held/Capaccioli/Cappellaro/Sparke/Mackie, MPI time.

September 1992: MPI time, Caux/Monin/Boulard/Lagrange-Henri, Surdej et al. (2-003-43K), Capaccioli/Piotto/Bresolin, Barbieri et al. (2-007-43K), Capaccioli/Piotto/Bresolin.

1.5-m Spectrographic Telescope

April 1992: Goudfrooij/de Jong/Jørgensen/Nørgaard-Nielsen/Hansen, Baade/Kolb/Kudritzki/Simon, Hensberge et al. (5-005-45K), Baade/Kolb/Kudritzki/Simon, Mantegazza/Arellano Ferro, Courvoisier/Bouchet/Blecha, Jørgensen/Rasmussen/Franx, Bertola/Amico/Zeilinger.

May 1992: Bertola/Amico/Zeilinger, Krautter/Wichmann/Alcala/Schmitt/Zinnecker, Lorenz/Drechsel/Mayer, Bogaert/Hu/Waelkens, Kunkel/Zinnecker/Schmitt.

June 1992: Böhringer et al. (1-023-49K), Gerbaldi et al. (5-004-43K), Thé/van den Ancker/de Winter, Ng/Kerschbaum/Habing/Hron, Schmid/Schild, Prugniel/Rampazzo/Sulentic/Combes/Hes/Amram.

July 1992: Prugniel/Rampazzo/Sulentic/Combes/Hes/Amram, Bianchini/Della Valle/Ögelman/Orio/Bianchi, Jockers/Böhnhardt/Thomas/Kiselev, Courvoisier/Bouchet/Blecha, Habing et al. (5-007-45K), Greve/McKeith, Acker/Cuisinier/Köppen/Rolla/Stasinska/Testor.

August 1992: Acker/Cuisinier/Köppen/Rolla/Stasinska/Testor, Pottasch S.R./Manchado/García Lario/Sahu K.C., Zeilinger/Møller/Stiavelli, Christensen/Sommer-Larsen/Beers/Flynn.

September 1992: Christensen/Sommer-Larsen/Beers/Flynn, Reimers et al. (2-009-45K), Gerbaldi et al. (5-004-43K), Spinoglio/Malkan/Rush, Danziger et al. (6-003-45K), Schwope/Beuermann/Thomas, Barbieri et al. (2-007-43K).

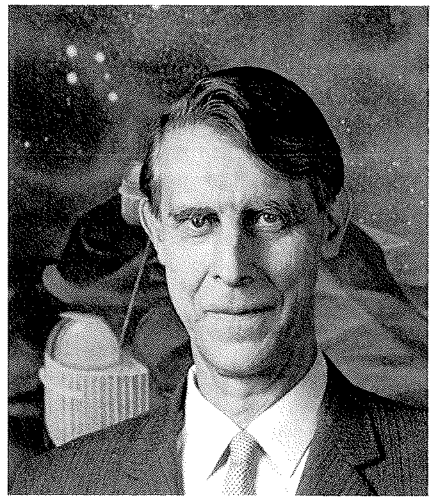
1.4-m CAT

April 1992: Baade/Kolb/Kudritzki/Simon, De Jager/Achmad/Nieuwenhuijzen, Waelkens/Conlon/Dufton, North/Glagolevski, Bossi/Mantegazza/Poretti/Riboni, Mathias/Gillet.

May 1992: Mathias/Gillet, Randich/Cratton/Pallavicini/Pasquini, Gratton/Sneden, Nussbaumer/Mürset/Schmid/Schmutz, Gustafsson/Andersen J./Edvardsson/Nissen, Gustafsson/Andersen J./Edvardsson/Nissen, Stefl/Baade/Balona, Gredel/van Dishoeck.

June 1992: Gredel/van Dishoeck, Kaper/Bhattacharya / Blondin / Hammerschlag / Takens/Tziotziu, Gredel/van Dishoeck, Kaper/Bhattacharya / Blondin / Hammerschlag / Takens/Tziotziu, Lagrange-Henri/Jaschek M./Jaschek C., Aerts/Waelkens, Mathys/Landstreet/Lanz.

Gösta W. Funke 1906–1991



Gösta W. Funke, former President of the ESO Council, died at the age of 85. He spent the main part of his very active life in the advancement of scientific research, on furthering the understanding of the importance of research for society, and advocating the application of rational principles in the solution of problems in society.

Funke was born on October 27, 1906. He received his Ph.D. and became Associate Professor at Stockholm University in 1937. He taught Mathematics and Physics in secondary school until 1944. From then until his retirement in 1972, Funke worked in different positions in the Natural Science Research Council and the Atomic Research Council. It can be claimed without exaggeration that his contribution was of extraordinary importance for the development and achievements of these Councils. His vivid interest and his knowledge provide the right conditions for constructive initiatives for both basic research and applications in many areas of society. His consistently claiming the importance of rational action in academic as well as other contexts was not always popular in all quarters, but it found a permanent echo among the members and staff of the Councils, and also among the promoters of research in Sweden and abroad.

Funke played an important role also in international research. Apart from cooperation within the Nordic countries, he took a particular interest in improving the links to France, a country which had (perhaps due to the language barrier) become unjustly neglected in Swedish research contacts, in spite of the obvious excellence of French science.

Funke contributed to the creation of the European research organizations CERN (for particle physics) and ESO (for astronomy). He was a Swedish delegate in both CERN and ESO; chairman of their Councils in 1967–69 and 1966–68 respectively. Further, he was Swedish delegate in NORDITA (for atomic research). He also contributed to the creation of the EMBL laboratory (for molecular biology).

Funke took a great interest in the application in society of results from scientific research, in the relations between technology and society, and in the protection of man against harmful effects of modern technology.

P. O. LINDBLAD

Although his involvement with ESO affairs may not date from the earliest consultations, in the 1950s, between leading personalities among whom Bertil Lindblad on behalf of Sweden, in a broader sense Funke may be rightly ranked among the Founding Fathers of our Organization. He was a member of the ESO Finance Committee from the date of the ratification of the Convention in 1964, and when soon after that, in 1965, Bertil Lindblad passed away shortly after having become President of the Council, Funke was the natural choice for being elected to this Office. He served in this capacity until the end of 1968 and remained a Council member for many years after.

A steady supporter of the aims of ESO throughout its early development and convinced of the necessity of European collaboration in scientific endeavour, Funke also was instrumental in pursuing these goals in times of ESO's early growing pains. Thus, when in 1969 Council resolved to appoint a small Working Group for reviewing certain administration procedures and staff problems, Funke was asked to chair this Group. He also played an important role in the new approach ESO followed in 1970 for the realization of the 3.6-m Telescope, when it was decided to sollicit for this project the collaboration of CERN. As a President of the CERN Council at that time, Funke was in a position to pave the way for CERN's decision to enter this collaboration. The wholehearted way in which this project then was pursued from the side of CERN led to the ESO TP Divisions's already that same year starting its work on the CERN premises.

Funke was an efficient chairman, with a sober, no-nonsense approach and a sense of humour. His contribution to ESO will be remembered with admiration and sympathy.

A. BLAAUW

July 1992: Mathys/Landstreet/Lanz, Lagrange-Henri/Loinard/Bouvier/Gomez/Bertout, Benvenuti/Porceddu/Krelowski, Magain/Zhao, Pogodin, Nussbaumer/Mürset/Schmid/Schmutz, Jorissen/Mayor/North.

August 1992: Jorissen/Mayer/North, Van Paradijs/Schrijver/Verbunt/Zwaan/Schmitt/Piters/Rutten.

September 1992: Berrios Salas/Fernández/Char/Maldini/Guzmán, Favata/Sciortino/Micela/Barbera.

1-m Photometric Telescope

April 1992: Jourdain de Muizon/d'Hendecourt/Puget, Courvoisier/Bouchet/Blecha, de Jager/Achmad/Nieuwenhuijzen, Bruch/Schimpke, Cacciari/Clementini.

May 1992: Cacciari/Clementini, Courvoisier/Bouchet/Blecha, Van der Hucht/Thé/Williams, Randich/Gratton/Pallavicini/Pasquini, Pottasch S.R./Manchado/García Lario/Sahu K. C. Mottola/Di Martino/Gonano/Neukum, Di Martino/Mottola/Gonano-Beuer/Neukum.

June 1992: Di Martino/Mottola/Gonano-Beuer/Neukum, Courvoisier/Bouchet/Blecha, Lagrange-Henri/Loinard/Bouvier/Gomez/Bertout, Habing et al. (5-007-45K), Ng/Kerschbaum/Habing/Hron, Alcaino/Liller/Alvarado/Wenderoth.

July 1992: Alcaino/Liller/Alvarado/Wenderoth, Courvoisier/Bouchet/Blecha, Habing et al. (5-007-45K), Fulchignoni/Barucci/Coradini/Burchi.

August 1992: Fulchignoni/Barruci/Coradini/Burchi, Panagi/Andrews/Houdebine/Foing, Lagerkvist/Magnusson/Eriksson.

September 1992: Lagerkvist/Magnusson/Eriksson, Lorenzetti/Molinari.

50-cm ESO Photometric Telescope

April 1992: Kohoutek, de Jager/Achmad/Nieuwenhuijzen, Bossi/Mantegazza/Poretti/Riboni.

May 1992: Bessi/Mantegazza/Poretti/Riboni, Lorenz R./Drechsel/Mayer, Magnan/Mennessier/de Laverny, Oblak et al. (7-009-49K), Gieren/Covarrubias.

June 1992: Gieren/Covarrubias, Wolf/Mandel/Spiller/Stahl/Szeifert/Zickgraf/Jüttner/Sterken.

July 1992: Wolf/Mandel/Spiller/Stahl/Szeifert/Zickgraf/Jüttner/Sterken.

August 1992: Magnan/Mennessier/de Laverny, Panagi/Andrews/Houdebine/Foing, Oblak et al. (7-009-49K), Sinachopoulos, Berrios Salas/Fernández/Char/Maldini/Guzmán.

September 1992: Berrios Salas/Fernández/Char/Maldini/Guzmán, Magnan/Mennessier/de Laverny, Hainaut/Detal/Pospieszalska-Surdej/Schils.

GPO 40-cm Astrograph

April 1992: Debehogne/Lopez/Garcia/Machado/Caldeira/Vieira/Netto/Lagerkvist/Mourao/Protitch-Benishek/Javashir.

May 1992: Debehogne/Lopez-Garcia/Machado/Caldeira/Vieira/Netto/Lagerkvist/Mourao/Protitch-Benishek/Javanshir, Munari/Lattanzi/Massone.

June 1992: Munari/Lattanzi/Massone, Scardia.

July 1992: Debehogne/Lopez/Garcia/Machado/Caldeira/Vieira/Netto/Lagerkvist/Mourao/Protitch-Benishek/Javanshir.

August 1992: Debehogne/Lopez-Garcia/Machado/Caldeira/Vieira/Netto/Lagerkvist/Mourao/Protitch-Benishek/Javanshir, Vidal-Majar et al.

September 1992: Vidal-Madjar et al.

1.5-m Danish Telescope

April 1992: West/Hainaut/Marsden/Smette, Surdej et al. (2-003-43K), Goudfrooij/de Jong/Jørgensen H.E./Nørgaard-Nielsen/Hansen, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Mayor et al. (5-001-43K). Danish time.

May 1992: Danish time, Nordström/Andersen J., Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Surdej et al. (2-003-43K), Ortolani/Barbuy/Bica, Prugniel/Rampazzo/Sulentic/Combes/Hes/Amram.

June 1992: Surdej et al. (2-003-43K), van der Klis/Augusteijn/Kuulkers/van Paradijs, Surdej et al. (2-003-43K), Danish time.

July 1992: Danish time, Mayor et al. (5-001-43K), Surdej et al. (2-003-43K), Tosi/Greggio/Marconi/Ferraro, Surdej et al. (2-003-43K), van Groningen/Miley/Chatzichristou/Keel/Heckmann.

August 1992: van Groningen/Miley/Chatzichristou/Keel/Heckman, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Surdej et al. (2-003-43K), Jorissen/Mayor/North, Duquennoy/Mayor, Danish time.

September 1992: Danish time, Ardeberg/Lindgren/Lundström, Ardeberg/Lindgren/Lundström, Wagner/Brinkmann/Voges/Heidt, Barbieri et al. (2-007-43K), Warren/Iovino/Shaver, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Surdej et al. (2-003-43K).

90-cm Dutch Telescope

April 1992: Covino/Krautter/Alcala/Chavarria/Terranegra, Dutch time.

May 1992: Dutch time, Oblak et al. (7-009-49K), Hahn/Lindgren M./Lagerkvist/Maury, Della Valle/Melnick, Turatto et al. (4-004-45K).

June 1992: Prugniel/Rampazzo/Sulentic/Combes/Hes/Amram, Wendker/Heske, De Winter/Thé, Van Dessel/Sinachopoulos, Prugniel/Rampazzo/Sulentic/Combes/Hes/Amram, Turatto et al. (4-004-45K), Schwarz/van Winckel/Corradi.

July 1992: Della Valle/Melnick, Schwarz/Corradi / van Winckel, Duerbeck / Vogt / Leibowitz, Dutch time.

August 1992: Dutch time, Oblak et al. 7-009-49K), Longo/Busarello/Rifatto, Lagerkvist/Dahlgren/Williams/Fitzsimmons, Della Valle/Melnick.

September 1992: Freudling/Alonso/DaCosta/Wegner, Weiss/Schneider/Gelbmann/Kuschnig, Ferrari/Bucciarelli/Massone/Koornneef/Lasker/Le Poole/Postman/Siciliano/Lattanzi, Turatto et al. (4-004-45K), Della Valle / Melnick, Schwope / Beuermann, Thomas.

50-cm Danish Telescope

April 1992: Jønch-Sørensen/Andersen M.I., Danish time.

May 1992: Danish time, Stefl/Baade/Balona, Gosset/Manfroid/Vreux/Smette, Stefl/Baade/Balona.

June 1992: Stefl/Baade/Balona, Danish time, Group for Long Term Photometry of Variables.

July 1992: Group for Long Term Photometry of Variables.

August 1992: Group for Long Term Photometry of Variables, Ardeberg/Lindgren/Lundström.

September 1992: Ardeberg/Lindgren/Lundström, Group for Long Term Photometry of Variables.

ANNOUNCEMENT

ESO/EIPC Workshop on Structure, Dynamics and Chemical Evolution of Early-Type Galaxies

Marciana Marina, Isola d'Elba, 25-30 May, 1992

A joint ESO/EIPC Workshop on Structure, Dynamics and Chemical Evolution of Early-Type Galaxies will be held from 25 to 30 May, 1992, at the Elba International Physics Centre, Marciana Marina, Isola d'Elba, Italy.

Topics of the workshop:

- Physical properties of early-type galaxies
- Subsystems in early-type galaxies
- Dark matter
- Formation and dynamical modelling
- Chemical evolution and stellar populations
- Nuclear and non-nuclear activity
- X-ray emission

Organizing Committee:

R. Bender (Heidelberg), F. Bertola (Padova), M. Capaccioli (Padova), I.J. Danziger (ESO), F. Ferrini (Pisa), M. Stiavelli (Pisa), W. Zeilinger (ESO)

Contact Address:

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Karl-Schwarzschild-Str. 2, D-W 8046 Garching bei München, Germany

PROFILE OF A KEY PROGRAMME:

A Galaxy Redshift Survey in the South Galactic Pole Region

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Introduction

The determination of the fundamental parameters of the galaxy distribution and of the typical scales of the spatial inhomogeneity of the Universe is an outstanding astrophysical problem. On the one hand, the galaxy distribution observed in the nearby Universe is highly inhomogeneous. On the other hand, the observed isotropy of the Cosmic Microwave Background strongly suggests that the Universe is homogeneous on very large scales. Spatial homogeneity lies at the basis of the "standard" Friedmann-Robertson-Walker cosmological model: *it is of fundamental importance to determine whether and on which scales homogeneity is reached* (Stoger et al., 1987, Scaramella et al., 1991). This information has also great relevance for the reliable determination of the zero-point, "local" (on a cosmological scale) properties of the luminous Universe, such as the galaxy luminosity function and the correlation function of galaxies and systems of galaxies. Well-determined zero-points are critical to several tests of cosmic models.

Our present view of the galaxy distribution within the "local" Universe is mainly the product of the observational efforts of the last decade and is based on several qualitative evidences but on few *reliable* measurements of the galaxy distribution. This picture cannot be confidently extrapolated to the unsurveyed Universe since none of the available galaxy surveys appear to cover a "fair sample" of the Universe yet (see below). Therefore, even the best measurement of the galaxy distribution might change as the size of the sampled Universe increases in depth and/or angular extent. Some important properties of the galaxy distribution have been convincingly demonstrated by the existing observations as, for example:

1. Galaxies are clustered on scales less than 10 h^{-1} Mpc in dynamical systems of different richness (from poor groups to rich clusters). Clusters are, in turn, clustered in superclusters on scales of about 25–30 h^{-1} Mpc (for a review see Bahcall (1988)).

2. Large underdense regions, "voids", have been detected in the redshift maps of the galaxy distribution. We assume here, and in what follows, that redshift maps are good representations of the true three-dimensional spatial distribution on scales larger than 10 h^{-1} Mpc. The sizes of the largest voids detected so far are of the order of 50 h^{-1} Mpc. It is important to note, however, that the largest detected voids are as large as they can be, given the depth and/or the areal coverage of the existing surveys (for a review see Rood, 1990).

3. The "field" galaxies around the voids form structures which are connected and bidimensional. Their typical thickness is about 500 km sec^{-1} (de Lapparent et al., 1991, Ramella et al., 1992).

Furthermore, there are other potentially very exciting observations which still await further confirmation and/or deeper understanding as, for example:

(1) The large-scale peculiar streaming motions of galaxies (i.e. gravitationally induced distortions of the Hubble flow).

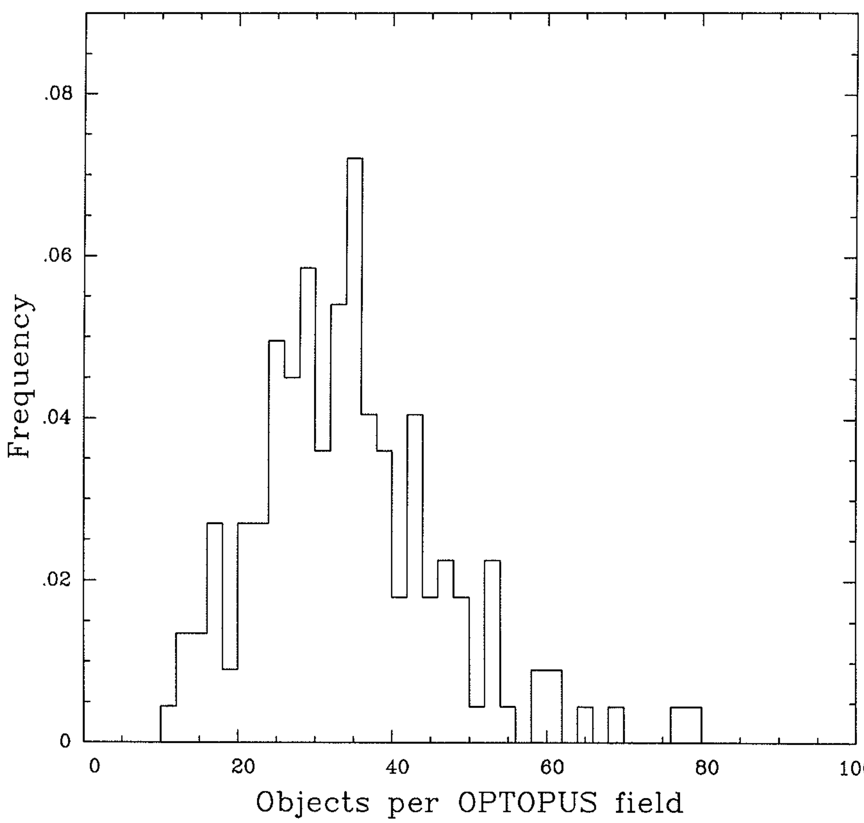

Figure 1: *Histogram of the number of galaxies brighter than* b_j *= 19.4 per OPTOPUS field in the area of our survey.*

Detected outside the Local Supercluster, their origin and interpretation is still largely debated.

(2) The rapid luminosity evolution of galaxies. The amount and the details of the inferred evolution rate depend critically on the shape and normalization of the luminosity function at present times (Colles et al., 1990, Maddox et al., 1990). As already noticed, the local luminosity function of galaxies is rather poorly known.

(3) The detection of periodical peaks in the distribution of galaxies in two deep ($z \geq 0.3$) pencil beam surveys in opposite directions. The period is of the order of 130 h^{-1} Mpc (Broadhurst et al., 1990, BEKS). These beam surveys have, however, such a small areal coverage that the noise induced by the small-scale clustering may significantly reduce the significance of the detection of peaks from which the periodicity is derived.

As already mentioned above, despite the large amount of the existing observational work, we still lack a "fair sample" of the Universe (for a definition of "fair sample", see Peebles, 1973). In fact, the average properties of the observed structures are different even in different surveys of similar depth but covering different areas of the sky. For example, the first "slices" of the CfA extended survey (see Geller, 1989) are dominated by the presence of thin (about 5 h^{-1} Mpc), bidimensional sheets surrounding voids which have typical sizes ranging from 30 to 60 h^{-1} Mpc. On the contrary, a "filament" (the Perseus Supercluster) is the dominating structure detected by the Arecibo survey. This survey is oriented orthogonally with respect to the CfA survey and is of comparable depth (see Haynes and Giovanelli, 1989). The Perseus Supercluster is extended along the right ascension direction throughout the survey, i.e. it is about 50 h^{-1} Mpc long. The other two dimensions, width and thickness, are both roughly 5 h^{-1} Mpc.

Because of the lack of a fair sample, even the values of fundamental quantities such as the *mean number density of galaxies* have so far been determined with significant uncertainties (deLapparent et al., 1989). Therefore, even more uncertain are the results of less direct and more sensitive statistical estimators, such as the two- and three-point correlation functions, the void probability function, the multifractal spectrum and the genus of the isodensity surfaces. For these reasons the possible comparisons between the data and both the linear and non-linear (N-body) predictions of various cosmogonic theories are relatively poor. However, even within the large observational uncertainties, no theory can yet account for *all* the observed features of the galaxy distribution, from the small ($\leq$ 10 h^{-1} Mpc) to the large ($\gg$ 10 h^{-1} Mpc) scales. Several scenarios have been investigated to model the formation and evolution of the large-scale structure. Many of them consider dark matter as the main constituent of the Universe and assume a closure value for the mass density ($\Omega = 1$). Since the best discriminative power of most models lies at large scales ($\gg$ 10 h^{-1} Mpc), observations of a fair sample of the galaxy distribution on these scales would allow us to discriminate among different theories.

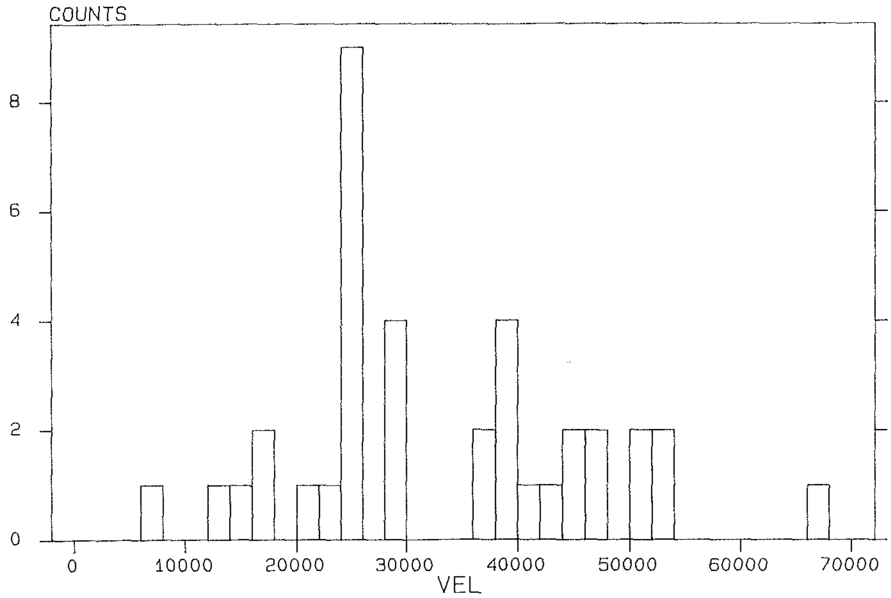

Figure 2: *Histogram of the redshift distribution of the galaxies in one OPTOPUS field.*

The Survey

The main goal of the present survey is to study and constrain the space distribution of galaxies at very large scales ($\geq$ 100 h^{-1} Mpc) and to address most of the critical aspects of the large-scale structure we discussed above. Our adopted observational strategy meets the following requirements:

(a) it can be completed in a reasonable number of nights and it is well tuned to the existing ESO instrumentation;

(b) it is wide enough to ensure the detection of most structures above the small clustering noise;

(c) it has one angular dimension and a depth which are large enough to detect structures on scales larger than those previously known (50–100 h^{-1} Mpc);

(d) it is characterized by a well-defined selection function which will allow us to measure the galaxy luminosity function, should the survey show that no structures larger than 100 h^{-1} Mpc exist.

We use the multifiber spectrograph (OPTOPUS) presently available at the Cassegrain focus of the 3.6-m ESO telescope at La Silla. In its present configuration, OPTOPUS allows us to obtain spectra for up to about 45 objects (plus 5 sky exposures) simultaneously in a field of 32 arcmin diameter.

Our strategy is to cover a rectangular strip of 23 × 1.6 degrees with three adjacent lines of 46 tangent OPTOPUS fields. We plan to observe all galaxies with $b_j \leq 19.4$ in each field. The total area sampled by these fields is 27 square degrees corresponding to about 70% of the total area of the strip. The strip is centred near the South Galactic Pole, to minimize absorption problems.

We extracted the list of our targets from the Edinburgh-Durham Southern Galaxy Catalogue which is based on digitized scans of UK Schmidt plates made by the Cosmos measuring machine. This catalogue (see Heydon-Dumbleton et al., 1988 for a detailed description) is complete to the limiting magnitude $b_{j,lim} \simeq 20.5$ and is of extremely high quality. Both the algorithm for star-galaxy separation and the constancy from plate to plate of the magnitude scale have been extensively tested. Interplate limiting magnitude variations are smaller than 0.04 magnitudes, and the internal measurement accuracy for individual magnitudes within a plate is of the order of 0.03 magnitudes. It represents therefore an ideal data-base for performing a deep redshift survey.

Figure 1 shows the histogram of the number of galaxies brighter than b_j =

19.4 in 155 OPTOPUS fields. The average number of galaxies is 35 per field and 75 % of the fields contain 20 to 40 galaxies, which is perfectly suitable for OPTOPUS.

With a limiting magnitude $b_{j,lim} = 19.4$, the effective depth of the survey is about 600 h^{-1} Mpc ($z \sim 0.2$). At this depth our strip has an area of about $3.7 \cdot 10^3$ (h^{-1} Mpc)^2 and includes a volume of about $7.4 \cdot 10^5$ (h^{-1} Mpc)^3. The total number of redshifts expected in our survey is $\simeq 5000$.

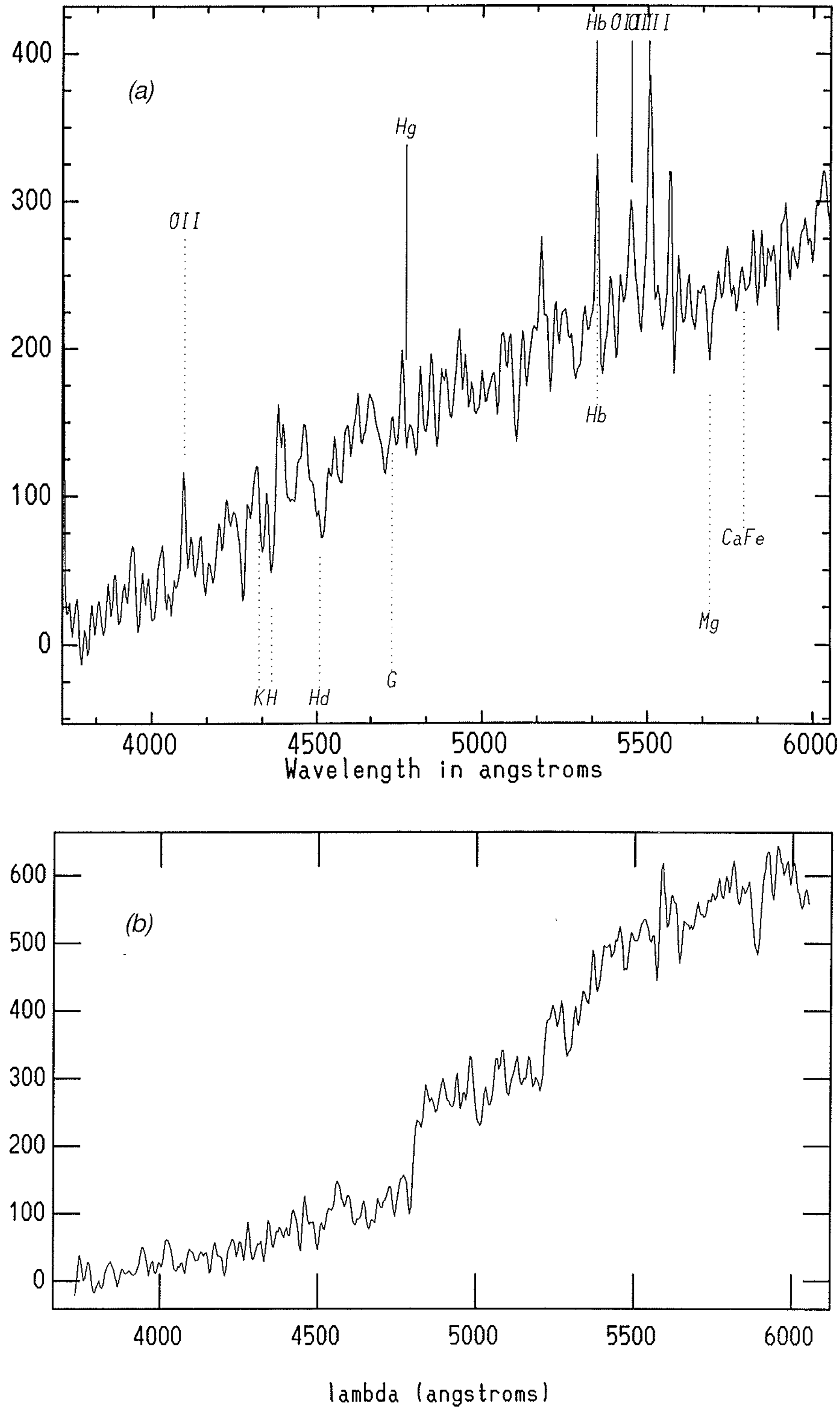

Figure 3, panel (a): *Optopus spectrum of a galaxy of* $b_j = 19.3$ *at* $z = 0.10$*; panel (b): Optopus spectrum of a galaxy of* $b_j = 19.0$ $z = 0.208$*.*

Scientific Objectives

The main goal of our survey is to determine whether structures like "voids" and "walls" exist on scales larger than those seen in the much shallower surveys like the Arecibo, CfA and SSRS (Da Costa et al., 1988) surveys. Should the few structures seen in the shallow surveys turn out to be fairly typical for the galaxy distribution, then our survey will determine the average properties of these structures. In particular, our survey will provide a very accurate determination of the galaxy luminosity function.

(A) The size and the distribution of inhomogeneities on large scales

With respect to the detection of "voids" and "walls" the key characteristics of our survey are the following:

(1) A characteristic depth of $\simeq 600$ h^{-1} Mpc. This depth is ~ 6 times the depth of both the CfA and Arecibo surveys. While in principle we do not know how large the size of the largest inhomogeneity is, several evidences from other ongoing surveys of galaxies and of clusters of galaxies seem to indicate that homogeneity should be reached on scales $\simeq 50-100$ h^{-1} Mpc, well within the limit of our survey.

(2) A large extension in one angular coordinate (R.A.). At the depth where our survey has the maximum sensitivity to the structures, $z \simeq 0.15$, the linear dimension corresponding to 23 degrees is $\simeq 170$ h^{-1} Mpc. This dimension is enough to cover 3 of the largest "voids" of the CfA survey. If our survey, deep rather than wide, will detect structures larger than $\simeq 100$ h^{-1} Mpc along the line of sight, its angular extension will be very important to discriminate between the peaks of the galaxy distribution corresponding to isolated clusters and those corresponding to the intersection with bidimensional connected structures or "walls".

(3) An extension in the other angular coordinate (DEC) sufficient to eliminate the problem of the small-scale clustering noise affecting the counts of galaxies in each distance bin. At $z \simeq 0.15$ the linear dimension corresponding to the width in declination (1.6 degrees) is $\simeq$ 12 h^{-1} Mpc, larger than the galaxy-galaxy correlation length. As Szalay et al., 1991) point out, the previous condition is necessary for a robust determination of the existence of "walls" in the galaxy distribution along the line of sight. The width of our survey will allow us to determine correctly the geometry of those connected structures which will be elongated in Right Ascension and roughly perpendicular to the line of sight, should they exist.

(4) A complete sampling of all the galaxies, within our limiting magnitude, in each OPTOPUS field. The complete sampling ensures that we will see all the structures with the highest possible signal-to-noise ratio, including those which might be poorly populated by groups

and clusters and still trace the Large-Scale Structure.

In addition, our survey will also be useful for a verification of the interesting and challenging BEKS results mentioned in the introduction. They have interpreted the observed peaks as the intersections of their pencil beam with regularly spaced "walls". Under this interpretation, structures like the Great Wall would be common in the universe and the scale of the "voids" would be of the order of 130 h^{-1} Mpc. However, the reality of the characteristic scale is still debatable and the need of a verification of the BEKS results derives essentially from the small angular size of their beam which is narrower than the "local" correlation length of the galaxies within the walls (Ramella et al., 1992). As a consequence, BEKS might have missed several walls and correspondingly overestimated the scale of the voids. This possibility seems to be supported by recent studies of the spatial distribution of clusters of galaxies in the region of BEKS probes, which show that the peaks strictly coincide with concentrations of clusters (see Chincarini et al., 1992 for discussion). On the other hand, there is no way to know whether all the peaks along their beam really correspond to "walls". In principle, at least some of the peaks might correspond to isolated clusters of galaxies. In this opposite case BEKS would have underestimated the scale of the "voids". Given the depth of our survey, we will cover distance equivalent to at least 5 of the peaks. Thanks to the angular extension of the survey we will be able to distinguish between isolated clusters and "walls", well above the small-scale clustering noise.

(B) Determination of the mean galaxy density and galaxy luminosity function

The existing shallow surveys might have already revealed the largest structures of the galaxy distribution. In this case our survey will represent a "fair sample" of the Universe. Therefore, the choice of a well-defined and controlled selection criterium for our galaxy list, i.e. the magnitude limit, allows us to measure both the shape and the normalization (i.e. the mean galaxy density) of the luminosity function of galaxies. As mentioned above, no survey, up to now, has yielded a "fair sample": the sizes of the inhomogeneities detected are as large as the sizes of the surveys. As a consequence, no truly reliable determination of the luminosity function has been possible yet.

A well-determined luminosity function is the key to several important measurements of the galaxy distribution. For example, the luminosity function must be known in order to measure the two-point correlation function of galaxies directly from magnitude-limited samples. A good determination of the luminosity function is also necessary to detect the effects of the evolution of galaxies on the galaxy counts. In fact galaxy counts at faint magnitudes ($b_j \geq 20$) are significantly higher than the euclidean predictions, while the redshift distribution of the same galaxies is in good agreement with those predictions. Galaxy evolution has been called for in order to explain the apparent paradox. The recent LDSS (Colless et al., 1990) survey, with a limiting magnitude of $b_j \leq 22.5$, does not detect any galaxy with z greater than 0.7 and strongly suggests that the required galaxy evolution must be luminosity dependent: the galaxies at the faint end of the luminosity function should evolve more rapidly than the galaxies at the bright end. Clearly, any evolution of this kind can only be measured if the *local* luminosity function and, in particular, its faint end is very well known.

(C) The statistical properties of clustering at large separations

The reliable determination of the statistical properties of galaxy clustering provides one of the key observational tests for any model aiming to explain the formation of the large-scale structure of the Universe. This is particularly true at large separations ($r \gg 10\ h^{-1}$ Mpc), where the theoretical framework is much simpler, since it is not complicated by the non-linear effects arising on smaller scales. By the use of several statistical methods, this allows one to directly study the properties of primordial density fluctuations (e.g. spectral shape, Guzzo et al., 1991, and possible luminosity segregation effects, Valls-Gabaud et al., 1989), which can powerfully discriminate among different cosmological models.

The First Observing Runs

Observations for the first two observing runs were made during nine nights in September and October 1991; unfortunately bad weather spoiled 5 nights. Some of the fields obtained so far have already been analysed. These data reassure us about the overall feasibility of the project.

Figure 2 shows the redshift distribution of the galaxies in one Optopus field. Figure 3 shows two spectra of galaxies at the magnitude limit of our survey. Two exposures of half an hour each were added. Radial velocities were measured using emission lines (for the object in panel (a) or cross correlating with galaxies of known radial velocity (for the object in panel (b). The overall accuracy of the redshifts so far measured ranges from 30 to 90 kms^{-1}.

References

Broadhurst, T.J., Ellis, R.S., Koo, D.C., Szalay, A.S., 1990, *Nature* **343**, 726.
Chincarini, G., Guzzo, L., Scaramella, R., Vettolani, G., Iovino, A., 1992 in *Clusters and Superclusters of Galaxies*, A.C. Fabian and M. Colless Eds., in press.
Colless, M., Ellis, R.S., Taylor, K., Hook, R.N., 1990, *MNRAS* **244**, 408.
Da Costa, L.N., et al., 1988, *Ap.J.* **327**, 544.
deLapparent, V., Geller, M., Huchra, J. 1989, *Ap.J.*, **343**, 1.
deLapparent, V., Geller, M., Huchra, J. 1991, *Ap.J.*
Geller, M., 1989, in 3rd ESO-CERN Symposium, M. Caffo, R. Fanti, G. Giacomelli, and A. Renzini Eds, Kluwer, page 83.
Geller, M., and Huchra, J., 1989, *Science* **246**, 897.
Guzzo, L., Iovino, A., Chincarini, G., Giovanelli, R., Haynes, M.P. 1991, *Ap. J. Lett.* **382**, L5.
Haynes, M., Giovanelli, R., 1989, in *Large Scale Motions in the Universe*, V.C. Rubin and G.V. Coyne Eds, Princeton University Press, page 31.
Heydon-Dumbleton, N.H., Collins, C.A., MacGillivray, H.T., 1988 in *Large Scale Structures in the Universe: Observational and Analytical Methods*, Seitter et al., Eds, Springer, page 71.
Maddox, S.J., Sutherland, W.J., Efstathiou, G., Loveday, J., and Peterson, B.A., 1990, preprint.
Peebles J. 1973, *Ap. J.* **185**, 413.
Ramella, M., Geller, M., Huchra, J., 1992, *Ap. J.* in press.
Scaramella, R., Vettolani, G., Zamorani, G., 1991, *Ap. J. Letters* **376**, 1.
Stoeger, W.R., Ellis, G.F.R., Hellaby, C., 1987, *MNRAS*, **226**, 373.
Szalay, A., Ellis, R.S., Koo, D.C., Broadhurst, T.J., 1991 in *After the First Three Minutes*, AIP Conference 222, page 261.
Valls-Gabaud, D., Alimi, J.M., Blanchard, A., 1989 *Nature* **341**, 215.

Correction

Two errors have been signalled by D. Hutsemékers in his article on "Unusual Solar Halos Over La Silla" (*The Messenger* No. **66**, page 18):

Figure 3 *should be rotated by 180 degrees* and line 5 in column 3 on page 19 should be read: "Fresnel formulae for reflectance times *the projected area* of the reflecting faces predict the intensity to be nearly constant . . ."

The New Gravitational Lens Candidate Q 1208+1011 and the Importance of High Quality Data

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1. Introduction

The ESO Key Programme "Gravitational Lensing: Quasars and Radio Galaxies" has been described by Surdej et al., 1989. One of the aims of this programme consists in identifying multiply imaged sources within a large sample of highly luminous quasars (HLQs). Indeed, both the so-called magnification bias and the redshift dependence of the optical depth for lensing point towards apparently bright and very distant objects as the best gravitational lens candidates. For this purpose, we acquire CCD images of these objects (hopefully under good seeing conditions) and carefully inspect the recorded frames, in search for multiple components or galaxies superimposed on the quasar image.

This visual inspection is, however, only a first step: we have now begun a systematic analysis of these CCD images using more sophisticated image-processing techniques, including deconvolution and point-spread function (PSF) subtraction. Up to now, we have analysed a sample of 153 quasars for which R-band images had been obtained. Most of these data come from the direct CCD camera at the 2.2-m telescope, from EFOSC at the 3.6-m and from the direct camera which was mounted at the NTT during its test period. Some of the results have been presented in September 1991 by Magain et al. (1992a) while a more complete statistical evaluation of gravitational lensing effects on HLQ images is in preparation (Surdej at al. 1992b).

The histogram of the image full width at half maximum (FWHM) is illustrated in Figure 1 for the 153 objects considered. The sharp peak at 0.7 arcsec corresponds to observations carried out at the ESO NTT, observations which took place only when the seeing was very good. The observations obtained during our regular observing runs correspond to the broader peak around 1.2 arcsec. The average seeing FWHM amounts to 1.0 arcsec for the whole sample.

These 153 HLQs were systematically inspected visually, in search for possible nonstellar images (extension, fuzz, . . .) or for companions, either stellar or diffuse. In addition, the PSF was subtracted from the quasar image whenever possible. The residuals were then examined for a possible superposition of a galaxy or of a stellar image.

2. PSF Subtraction

The PSF was determined from stellar images in the field of the quasar. An analytic profile, in the form of a generalized Moffat (1969) function, was fitted to all stellar images simultaneously, then subtracted. The residuals were recentred and a mean was computed. The composite PSF (analytic function + mean residual) was then fitted to all the images (quasar and stars) and subtracted. The final residuals were examined, and it was decided whether the quasar had been fitted satisfactorily or if a significant residual remained, in which case it was classified as "interesting". We then tried to identify the nature of the residual, either diffuse or point-like. In particular, a fit of two PSFs was attempted to see if the object could be modelled as a double image.

In the course of this systematic analysis, we encountered a number of problems, which are described below.

2.1 Non-linearities

First, it was found that, on the frames obtained with the ESO CCD # 5 (RCA, 30 μm pixels), the shape of the PSF was a function of the image level, the core of the brighter stellar images appearing flatter than for the fainter ones. That CCD had been used for the earlier observations at the 2.2-m telescope (i.e.

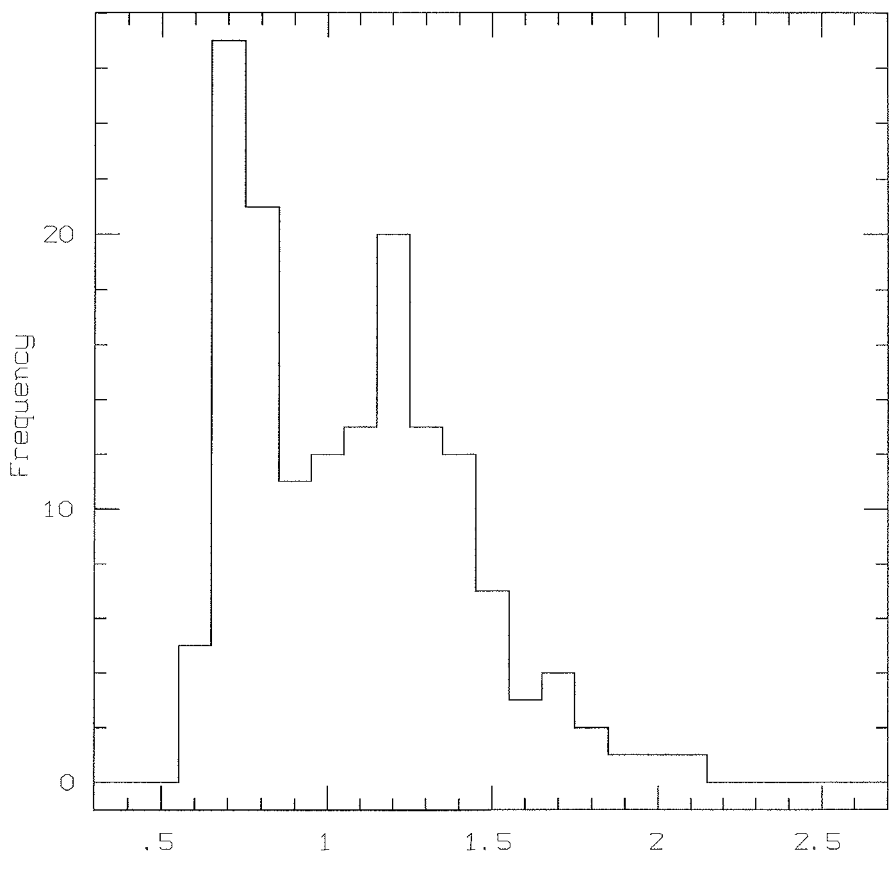

Figure 1: *Histogram of the image FWHM for the 153 quasars analysed.*

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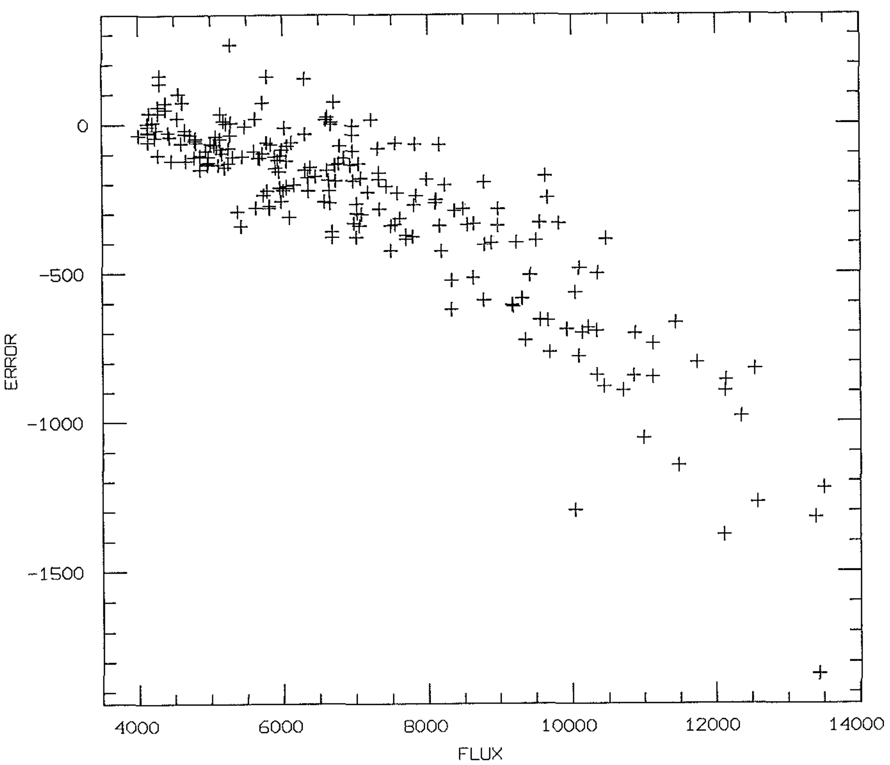

Figure 2: *Departure from linearity as a function of exposure level for the ESO CCD # 5. Both scales are in ADUs.*

from April 1987 to May 1988). We interpret this effect as caused by a non-linear response of the CCD, the recorded signal being non proportional to the amount of incident light. The amount of non-linearity could be estimated by self-calibration of the CCD images: the relation between light intensity and recorded signal was determined by requiring that the PSF shape be independent of the exposure level. That procedure was applied to all suitable images (that is, images containing several stars of various magnitudes) and the non-linearity curves derived from different frames were compared. This effect was found to be remarkably constant over the period covered by our data (4 runs, in April 1987, July 1987, November 1987 and May 1988). A mean curve was constructed and is presented in Figure 2. It shows a departure from linearity, having the form of a "saturation effect", reaching 10% at the highest exposure levels. If not taken into account, this would introduce severe photometric errors and would make any PSF subtraction meaningless, except in those cases where the quasar and the comparison star are equally bright. We thus corrected the recorded signal, prior to PSF subtraction, by the relation:

$$S_{\text{corr}} = \frac{S_{\text{obs}}}{a + b\, S_{\text{obs}}}$$

with a = 1.0382, b = −9.5565 10^{-6}. S_{obs} is the recorded signal (in ADU) and S_{corr} the signal corrected for the non-linearity. This relation is valid for signals above 4000 ADU. No correction was applied below that level.

2.2 Spatial variation of the PSF

A second problem encountered was the spatial variation of the PSF for the CCD frames obtained at the 3.6-m telescope with EFOSC, which is probably due to the rather complex optics of the instrument. This problem is illustrated in Figure 3, which was constructed in the following way. An exposure with a relatively good seeing (1.06 arcsec), and with rather isolated stars of suitable exposure level covering the whole field was selected. A mean PSF was constructed and subtracted from all stellar images used for its determination.

The residuals are shown in Figure 3 at their original position, but with a spatial scale which is expanded 6 times in order to improve their visibility. It is seen that these residuals (which should be negligible if the PSF shape was constant over the field) have a characteristic quadrupole shape, with an orientation depending on the position in the field. Indeed, if we draw straight lines originating from the centres of the stellar images and pointing in the direction of the residuals positive maxima, these lines would cross at approximately the same point, located somewhat to the left of the frame centre. This indicates that the stellar images are radially elongated, the centre of symmetry being slightly offset from the centre of the CCD image. The amplitude of these residuals amounts to 10% of the peak intensity of the stellar image, which is an important effect.

Since the shape of the PSF depends on the position in the field, this means that, unless we are able to model that variation, the PSF can only be subtracted from those quasar images for which stellar images can be found very nearby in the field and, preferably, on both sides of the quasar so that an interpolation can be carried out quite accurately. As a consequence, only very few of the images obtained with that instrument were found suitable for PSF subtraction.

2.3 PSF variation with exposure level

The third problem was totally unexpected: we found that the sharpness of the stellar images varies with their intensity, in such a way that the *brighter* images appear *sharper*, the FWHM decreasing by an amount of the order of 5% for a factor 10 in brightness. Moreover, it does not seem to affect the integrated signal, but just to redistribute the photons inside the stellar image, so that the photometry remains unaffected. This effect is present in data obtained with different instruments and different detectors, at different telescopes. However, its amplitude seems to depend on the configuration used. Unfortunately, our data do not allow to determine the origin of that effect: we suspect that it is due to the detector, but we cannot find any meaningful physical interpretation.

Figure 4 presents a plot of the PSF full width at half maximum (FWHM) for data obtained with the direct camera and ESO CCD # 11 at the 2.2-m telescope in April 1989.

In the absence of a physical explanation, we applied an empirical intensity-dependent correction to the PSF before subtracting it from the star and quasar images.

3. Results

The first and third problems encountered thus received an empirical correction, but, due to the number of parameters involved, the second one could not be modelled on the basis of the available data.

Given these problems, and given the facts (1) that some quasar images are not suitable for PSF subtraction because of a lack of comparison stars and (2) that the images obtained with the ESO NTT in the test period were not corrected for field rotation, we were left

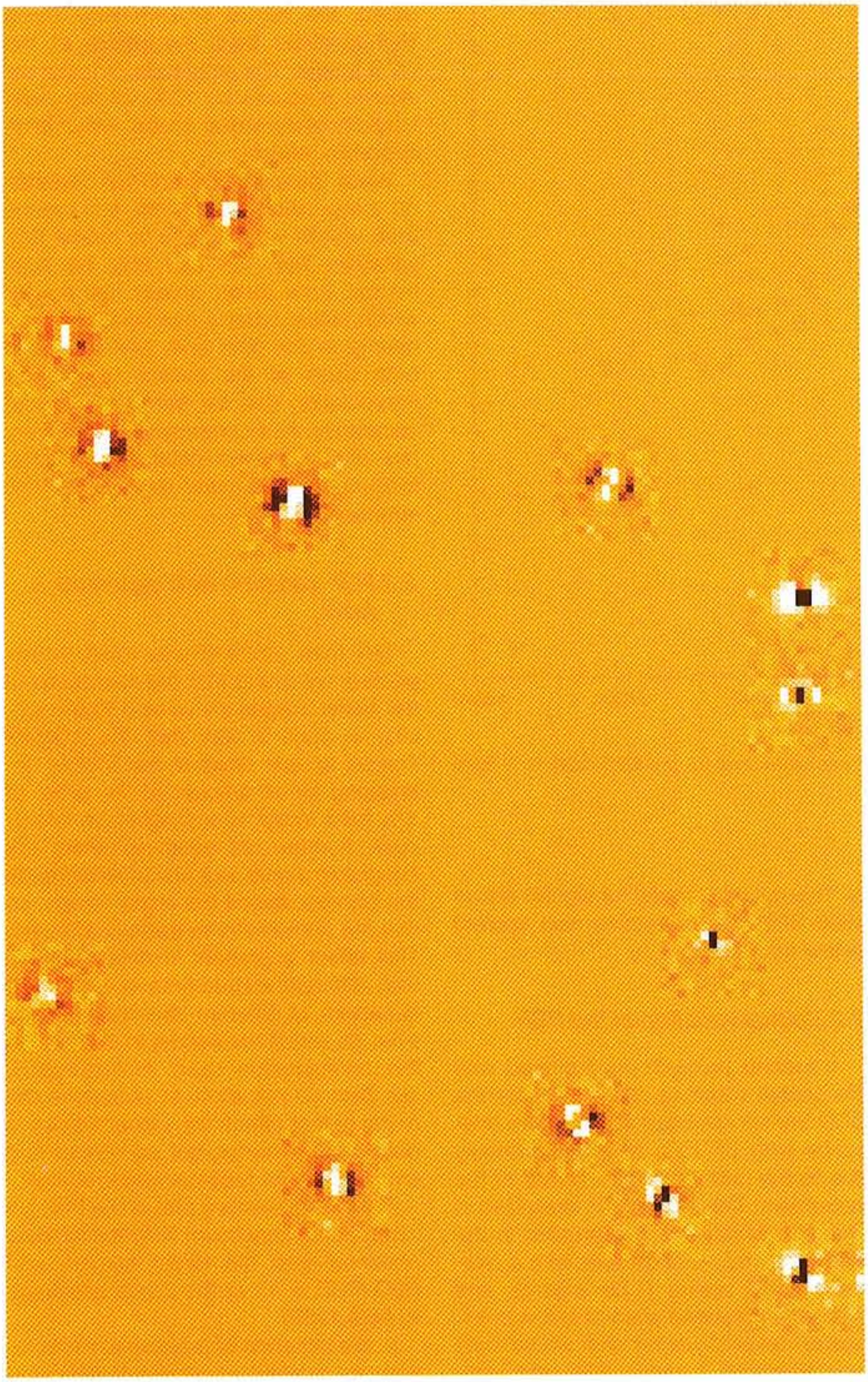

Figure 3: *Residuals of the PSF subtraction on an EFOSC image, showing the spatial variation of that instrument's PSF. See text for details.*

with 57 objects out of 153 for which the PSF could be satisfactorily subtracted.

The results concerning the superpositions of quasars with galaxies and the statistical frequency of lensing have been described by Magain et al. (1992a) and Surdej et al. (1992a). Here, we just wish to present the most spectacular result, which is the discovery of a new, rather extraordinary, gravitational lens candidate.

The quasar Q 1208+1011 was discovered by Hazard et al. (1986) and held for some time the world record with a redshift of 3.803. It is very luminous (M_v = –30.3) and, as such, was observed in April 1987 with the direct camera at the ESO/MPI 2.2-m telescope, the detector being a low-resolution RCA CCD (ESO # 5). We secured an R image, with an exposure time of 20 minutes. The seeing was rather poor (FWHM = 1.38 arcsec) and nothing special could be seen on the image. However, the PSF subtraction carried out in May 1991 revealed a very significant residual which could be interpreted as due to the presence of (at least) a second image.

Given these promising results, we decided to re-observe that object as soon as possible. New data could be obtained on July 7, 1991, with the direct camera at the 2.2-m telescope, equipped with a high resolution RCA CCD (ESO # 15). Two exposures were obtained, one with an R filter and the second with a B filter. The seeing was significantly better (0.9 arcsec for the R image) and the PSF subtraction confirmed the previous results. Two PSFs were then fitted to the R image of the quasar. The residual was then reduced to a negligible amount, showing that this object could be modelled by two point sources, separated by 0.45 arcsec and with a magnitude difference of 1.4 in the R band. Unfortunately, the B image is underexposed and no firm conclusion can be drawn from its analysis. Our first results were announced during the International Conference on Gravitational Lensing in Hamburg (Germany) on September 12, 1991 by Magain et al. (1992a). A more detailed account of that discovery may be found in Magain et al. (1992a).

In the meantime, we learned that Q 1208+1011 had been observed with the Hubble Space Telescope on July 22, 1991 in the framework of the snapshot survey (Bahcall et al., 1991). We obtained the image as soon as it became public, and were very pleased to see that it nicely confirms our results (Fig. 5).

In the absence of individual spectra of the two point sources, it is not possible to definitely conclude that Q 1208+1011 constitutes a new case of gravitational lensing. However, a good medium resolution spectrum of the whole system has been published by Steidel (1990). Interestingly enough, it shows strong absorption lines reaching nearly zero intensity. This allows to exclude the possibility that the fainter image corresponds to a foreground star. Indeed, the probability that such a star would have saturated absorption lines at precisely the same wavelengths as the high redshift quasar is essentially zero. Thus, we can conclude that Q 1208+1011 is either a binary quasar or a gravitational mirage. If the latter interpretation is the correct one, it implies that we have identified the multiply imaged quasar which is the most distant and with the smallest angular separation known up to date.

The fact that it could be detected on an image obtained in rather mediocre seeing conditions (1.38 arcsec) illustrates very clearly the power of adequate image analysis techniques. However, to be efficient, these techniques need to be applied to good quality data. This means: images obtained with a linear detector, with an instrument having a stable, well-defined PSF, and a good sampling (typically 0.1 arcsec per pixel). A sampling of 2 or 3 pixels per

FWHM would certainly not have allowed us to discover this very compact gravitational lens candidate.

Acknowledgements

Our research is supported in part by contract ARC 90/94-140 "Action de recherche concertée de la Communauté Française" (Belgium) and by an FNRS Grant (DH).

References

Bahcall, J.S., Maoz, D., Doxsey, R. et al. (1991): reprint.
Hazard, McMahon, R.G., Sargent, W.L.W. (1986): *Nature*, **322**, 38.
Magain, P. (1989): in Proceedings of the First ESO/ST-ECF Data Analysis Workshop, eds. P.J. Grosbøl, F. Murtagh and R.H. Warmels, ESO Conference and Workshop Proceedings No. 31, p. 205.
Magain, P., Hutsemékers, D., Surdej, J., Van Drom, E. (1992a): paper presented at the Hamburg International Conference on Gravitational Lenses, Hamburg (9–13 September 1991), to appear in the proceedings of the conference, Springer, *Lecture Notes in Physics* series.
Magain, P., Surdej, J., Vanderriest, C., Pirenne, B., Hutsemékers, D. (1992b): *Astron. Astrophys. Letters*, in press.
Moffat, A.F.J. (1969): *Astron. Astrophys.* **3**, 455.
Pirenne, Surdej, Magain: *ST-ECF Newsletter* **17**, 12–13, February 1992.
Steidel, C.C. (1990): *Ap. J.S.* **72**, 1.
Surdej, J., Arnaud, J., Borgeest, U. et al. (1989): *The Messenger* **55**, 18.
Surdej, J., Claeskens, J.F., Hutsemékers, D., Magain, P., Pirenne, B. (1992a): paper presented at the Hamburg International Conference on Gravitational Lenses, Hamburg (9–13 September 1991), to appear in the proceedings of the conference, Springer, *Lecture Notes in Physics* series.
Surdej, J. et al. (1992a): in preparation.

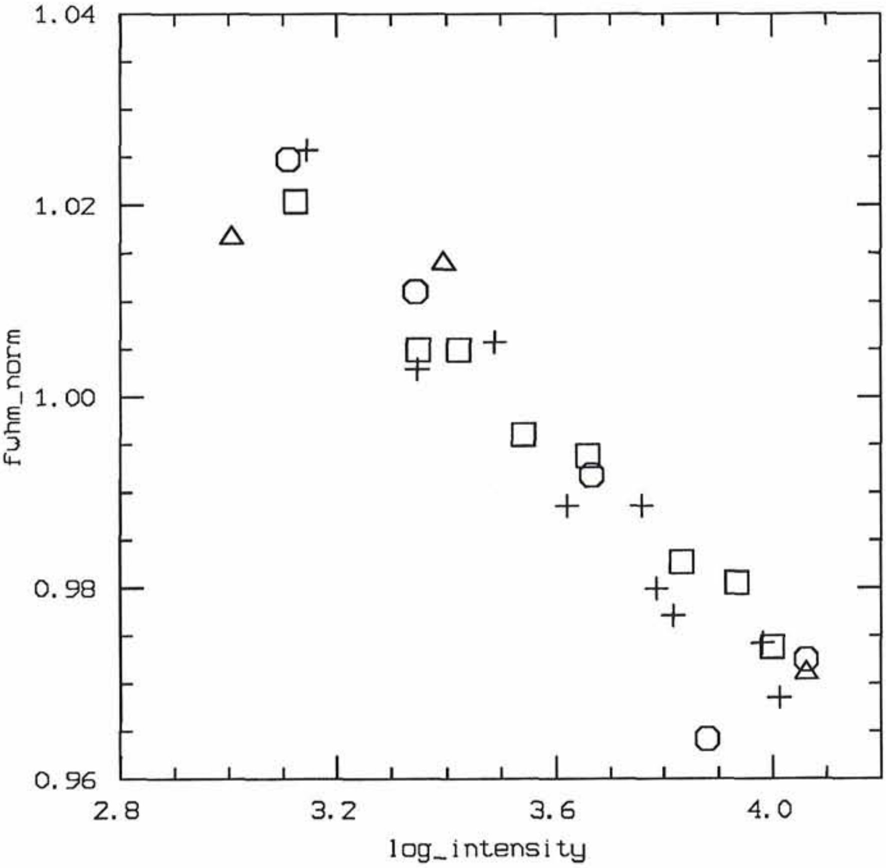

Figure 4: *The FWHM is plotted as a function of the logarithm of the central intensity for images obtained with ESO CCD # 11 at the 2.2-m telescope in April 1989. The FWHM is normalized to its value at log(intensity) = 3.5. Different symbols correspond to four different frames.*

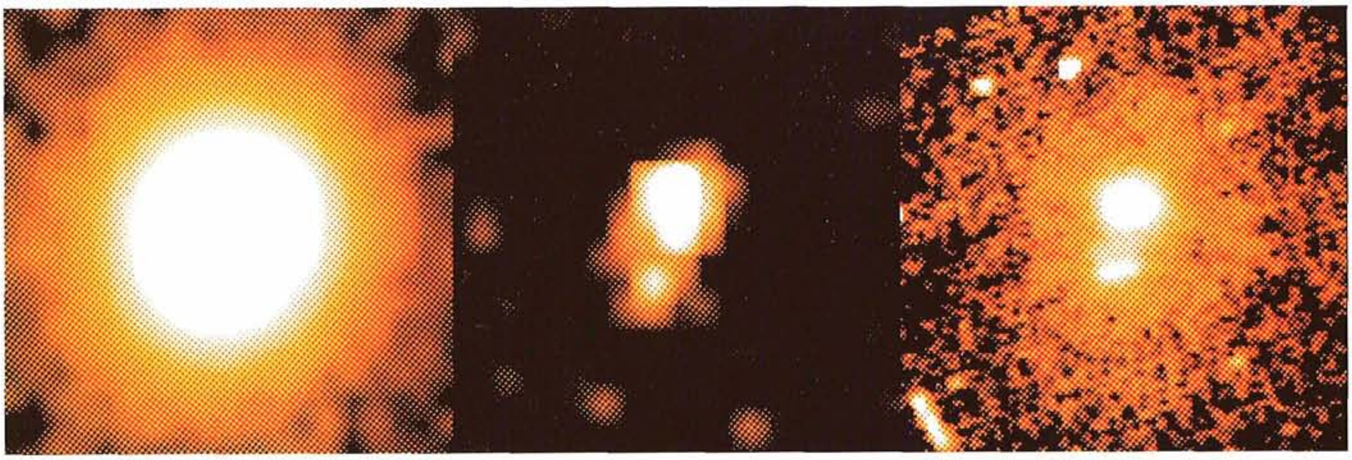

Figure 5: *Images of the highly luminous quasar Q 1208+1011. Left: ground-based image, seeing = 0.9 arcsec. Middle: deconvolution of the ground-based image using the algorithm described in Magain (1989). Right: HST image. These three images are re-sampled to the same scale and normalized to the same peak intensity. The intensity scale is logarithmic.*

Minor Planet Discovered at ESO is Named "Chile"

A minor planet which was first discovered on a photographic plate obtained with the ESO 1-metre Schmidt telescope in 1988 has now been named after the country in which the La Silla observatory is located.

The observation was made on February 13, 1988 by ESO night assistant Guido Pizarro, within the minor planet search programme by Belgian astronomer Eric W. Elst, who also found the new object on the plate. From a number of exact positions, measured on this and other ESO plates, a preliminary orbit was computed. Interestingly, it turned out that the new minor planet had been observed before; in 1931 at the Flagstaff observatory in Arizona, USA. However, no orbit could be computed at that time and according to IAU rules, Eric Elst is therefore the official discoverer. When further observations had been secured in 1990, it was given the number (4636).

Discoverers of minor planets have the privilege to propose names for them, which are then scrutinized by an IAU Committee and authorized, if they conform with certain rules. Elst, who is a long-time visiting astronomer to ESO-La Silla, noted that no minor planet had ever been named after Chile and decided to name the new planet after this country. As is customary, he also wrote a short explanatory citation.

This is the citation for "Chile", as it appears on the Minor Planet Circulars 19697-19698 (1992 Feb. 18):

(4636) Chile = 1988 CJ5

Discovered 1988 Feb. 13 by E.W. Elst at the European Southern Observatory.

Named for the beautiful South American country in which the European Southern Observatory is located. Noted for its great wines, Chile is chiefly mountainous, with the Andes dominating the landscape. The extension of Chile across some 38 degrees of latitude embraces nearly all climates. The fascinating Chilean people are racially a mixture of Europeans (the conquistadores from Spain, Basque families) and indigenous tribes (Atacamenos, Diaguitas, Picunches, Araucanians, Huilliches, Pehuenches and Cuncos). Today the proud Araucanian Indians form the only significant ethnic minority.

"Chile" revolves around the Sun once every 4.23 years in a slightly eccentric orbit at a mean distance of 391 million km from the Sun, i.e. between the planets Mars and Jupiter. The orbital elements have been published in Minor Planet Circular 17192. The size is not yet known with certainty, but judging from the brightness, it may be estimated that the diameter is in the 10-km range.

Congratulations to our host country and to the discoverer! *The editor*

Another Chiron-type Object

R. M. West, ESO

The Discovery of 1992 AD

The announcement on January 23, 1992 (IAU Circular 5434) of a new "slow-moving" object in the solar system has been met with great enthusiasm by minor-planet and cometary astronomers alike. It was first found by Dave L. Rabinowitz at the 91-cm Spacewatch camera on January 9 and then observed with the Arizona-based telescope during the following nights. More observations were made by Eleanor Helin at Palomar and Robert McNaught at Siding Spring and when an earlier image was found on a January 1 Palomar plate, it became possible for Gary Williams of the IAU Minor Planet Bureau to compute the first, reasonably accurate orbit (IAUC 5435).

To everybody's surprise, *1992 AD* – as it was now baptized – turned out to have the most extreme orbit of all known minor planets: with a semi-major axis of 20.5 AU and an orbital eccentricity of 0.58, it reaches aphelion at 32.4 AU, i.e. beyond the orbit of Neptune! The orbital period is no less than 92.5 years, and the inclination is rather high, almost 25°. 1992 AD passed through its perihelion at a heliocentric distance of 8.7 AU in late September 1991, only half a year before the discovery. This corresponds to the orbit of Saturn.

After the discovery of (2060) Chiron in 1977, 1992 AD is only the second minor planet to have been found in an orbit that is almost entirely beyond that of Saturn. Its existence strengthens the belief held by some astronomers that there is a whole group of objects out there, waiting to be discovered with the more powerful observational techniques now becoming available.

The magnitude of 1992 AD was measured on January 9 as V = 16.9 and David Tholen at the NASA Infrared Telescope Facility on Mauna Kea (Hawaii) commented on the unusually red colour of the object. Preliminary values of the diameter and the albedo (ability to reflect the sunlight) were measured by a group of astronomers in Arizona, headed by E. Howell. Comparing infrared and visual observations, obtained simultaneously with the MMT and the 1.5-m Catalina telescopes, they found about 140 km and 0.08, respectively; the latter is not all that different from the presently accepted value for Chiron, about 0.10. Thus 1992 AD and Chiron resemble each other, at least what concerns these parameters.

Figure 1.

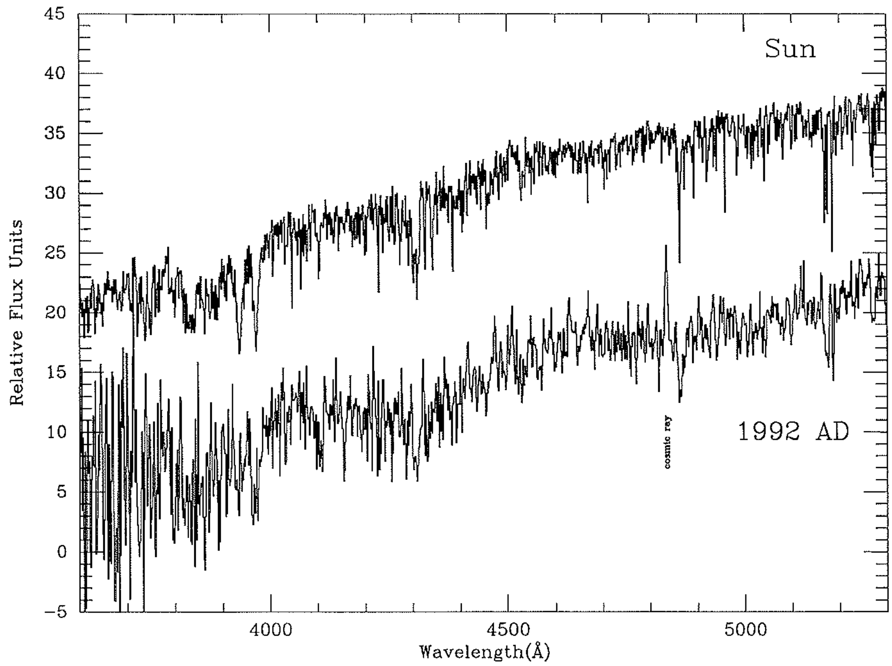

Figure 2.

ESO Observations

At ESO, three lines of investigations were initiated immediately after the announcement of the discovery.

With the Danish 1.54-m telescope, Olivier Hainaut and Alain Smette obtained deep CCD frames on February 2. In addition to measuring an accurate position, useful for improving the orbital computations, they checked whether 1992 AD has an atmosphere like is the case for Chiron since 1988. A 30-minute exposure is shown here (Fig. 1) and as can be seen, there is no sign of any diffuse "coma" around 1992 AD. In fact, by adding several CCD frames, the ESO astronomers were able to put quite low limits on any dust or gas above the surface of 1992 AD. It certainly looks completely inactive.

At the ESO/MPI 2.2-m telescope, Olivier Hainaut and Werner Zeilinger obtained a spectrum of 1992 AD, covering most of the visible region. A raw version of this spectrum is shown in Figure 2, together with the corresponding solar spectrum. Despite the rather poor response of the CCD in the UV-blue part of the spectrum, it seems clear that the overall forms of the spectra are similar, except that there may be some broad absorption structures in the spectrum of 1992 AD. No emission lines were found, so there is no indication of a gaseous atmosphere.

Thus, at least at the present time 1992 AD is dissimilar to Chiron in that it has no perceptible atmosphere.

Finally, a search was made for earlier images of 1992 AD, possibly visible on photographic plates available at the ESO Headquarters. Three ESO plates from 1977–78 and one UK Schmidt plate from 1982 were identified. A very faint trail was seen on the UKS plate.

However, when in February 1992 pre-discovery images were found on Palomar plates dating from January 1991 and November 1989, a backward orbital extrapolation showed that the object on the 1982 UKS plate was not 1992 AD. But fortunately Robert McNaught from the UK Schmidt team in Coonabarabran found the right object, of magnitude ~ 20 and about 10 arc-minutes distant from the other one, and he also identified 1992 AD on a 1977 UKS plate. A further verification of two ESO QBS plates from 1977 and 1978, now more accurate with the improved orbital data, still did not show the object, most certainly because the predicted blue magnitudes were 21.7 and 21.5, i.e. at the formal limiting magnitude of the ESO Quick Blue Survey.

The Importance of 1992 AD

The new minor planet moves in a part of the solar system that is largely unexplored. Only a few comets have been followed out to these distances, but the observations are very difficult and not very detailed. However 1992 AD and Chiron are bright enough to be observed over much of their orbits, especially when the new large telescopes enter into operation. They are most likely to represent the first (the brightest?) of a new class of minor planets which move in orbits beyond Saturn. Already at the time of the discovery of Chiron, it was inofficially decided that they will be given the names of mythological Centaurs, so they will supposedly be known in the future as the *Centaurs*, just like the Atens, Apollos, Amors, Hildas, etc. Now that 1992 AD has been observed in 1977, 1982, 1989, 1991 and 1992, the orbit is sufficiently well known to allow the assignment of a number and a name. No doubt the discoverers are now busy studying mythology!

In this connection, speculations have already been started about possible similarities between Chiron and 1992 AD on one side and some of the outer moons, like Triton at Neptune and Charon at Pluto, as well as Pluto itself. Are they perhaps all objects of the same basic type, but of different sizes and with different evolutionary histories? Only further observations will tell.

Nova Muscae 1991: One Year Later

M. DELLA VALLE, ESO-La Silla

X-ray novae form a subclass of low-mass X-ray binaries, which are systems usually composed of a low-mass late-type star and an accreting compact object as neutron star. For a few of them there exists the interesting possibility that the compact object may be a black hole. Thus the detection of the optical counterpart represents a first step towards the study of very compact objects in binary systems.

The X-ray transient source GRS 1121-68 was discovered by the WATCH all-sky X-ray monitor on the Soviet GRANAT satellite on January 9 (Lund and Brandt, 1991) and shortly thereafter by GINGA all-sky monitor (Makino, 1991). Its optical counterpart was furthermore identified as a star of V ~ 13.5 on a IIIa-J plate taken on January 13 with the 1-m Schmidt telescope (Della

Valle, Jarvis and West, 1991a) and later confirmed by X, and γ observations. The progenitor is barely visible on the best ESO (R) Schmidt plates (1984) with a magnitude close to the $B \simeq 20.8$.

Because of the binarity, Nova Muscae 1991 should be observable, also when the star reverts to minimum light; this post-outburst stage represents a most important phase for elucidating the *true* nature of the compact companion.

In the X-ray novae the spectrum of the late-type companion is overwhelmed by the continuum produced by X-ray heated gas. On the other hand, at minimum light the star should be at its minimum brightness, when the fraction of light due to X-ray heating is negligible. The present NTT frame (Fig. 1), obtained on January 1, 1992, i.e. almost exactly one year after the outburst, shows that the nova has in the meantime reverted to its original brightness and is now of magnitude $V = 20.5 \pm 0.1$.

Nova Muscae 1991 should therefore now provide the rare opportunity to observe the spectrum of the companion star. In this way it will be possible to determine the orbital parameters and, most important, to estimate the masses of the components.

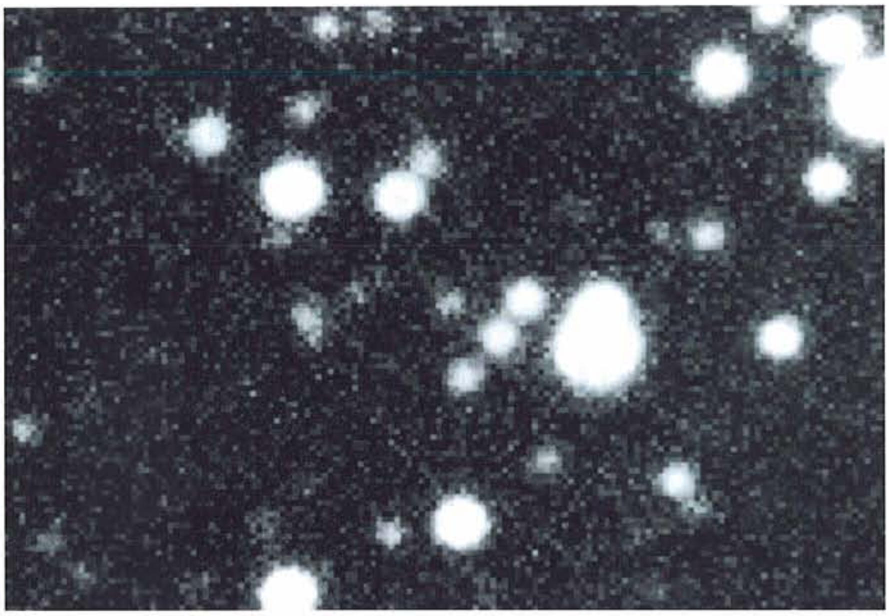

Figure 1: *Frame of Nova Muscae 1991, obtained on January 1, 1992 by E. Cappellaro with the NTT (V; 60 sec exposure). The object is at the centre of the field, just left of a chain of three stars (cf. also the images in the* Messenger, *No.* ***63***, *p. 3; March 1991), and the magnitude is V = 20.5. North is up and east is to the left.*

References

Lund, N., Brandt, S. 1991, *IAU Circ.* 5161.
Makino, F., and Ginga Team 1991, *IAU Circ.* 5161.
Della Valle, M., Jarvis, B.J., West, R. 1991, *Nature,* **353**, 50.

La Silla in the Sky

Johan H. Knapen (Tenerifa, Spain) took this unusual photo of La Silla and the surrounding landscape during a visit in March 1991 to the ESO Observatory. He says: "Around midday, while I was walking from the residence to the SEST telescope, where I was observing, I was struck by the colour contrast between the traffic mirror and the blue sky, the reflection of some of the La Silla telescopes and the grand view of the desert."

Light Echoes from SN 1987A

L. WANG[1] *and M. ROSA*[2]

[1]*ESO and Center for Astrophysics, the University of Science and Technology of China, Hefei Anhui, P.R. China;*
[2]*ST-ECF*

In the five years since the outburst of SN 1987A, light echoes have been used as an efficient way of studying the structure of the interstellar medium close to the supernova.

These echoes are evolving rapidly with time. The expansion rate of the ring was found to be approximately 3 arcsec per month, or about 25 times the speed of light (1). The new image shown here is from a 20-minute exposure taken at the NTT telescope with EMMI, using a filter with a central wavelength of 665.93 and FWHM of 6.64 nm. The size of the outer ring is now 125±3 arcsec and that of the inner ring is 73±2 arcsec. Both rings are brighter at the northern side than at the southern side. A new bright patch appeared at the northern top of the outer ring.

If these echoes arise from a sheet of dust cloud, its geometry is described by

$$\theta = (2b/D^2 \cdot c(t-t_o))^{1/2},$$

where b denotes the distance between the supernova and the dust cloud projected on the line of sight, D is the distance to SN 1987A, and t_o is the time interval between the explosion and the part of the light curve producing the echo (1). The parameters t_o and b were derived by Gouiffes et al. (1988) to be 60±17 days and 316±16 pc for the outer ring, and 40±32 days and 122±10 pc for the inner ring. In Figure 2, the above equation is plotted together with the measured points. The dotted lines are the solution of the above equation using the parameters derived from Gouiffes et al. (1988). No large deviations were recorded for both the inner and outer ring during the most recent observation, which is plotted as solid squares in the figure. For the inner ring a better fit is given by the solid curve in this figure, where the parameters t_o and b are found to be 20 days and 105 pc.

At position angle 165°–211°, there is another bright arc close to the outer ring, but it does not follow the curvature established by the other part of the outer ring. This arc has a very well defined sharp edge, and is apparently connected with the diffuse light outside it. A comparison with early data (cf. Gouiffes et al., 1988) shows that this was already there three years ago and shows no change in its location. This is therefore a physical structure whose nature is quite different compared with the two echoes.

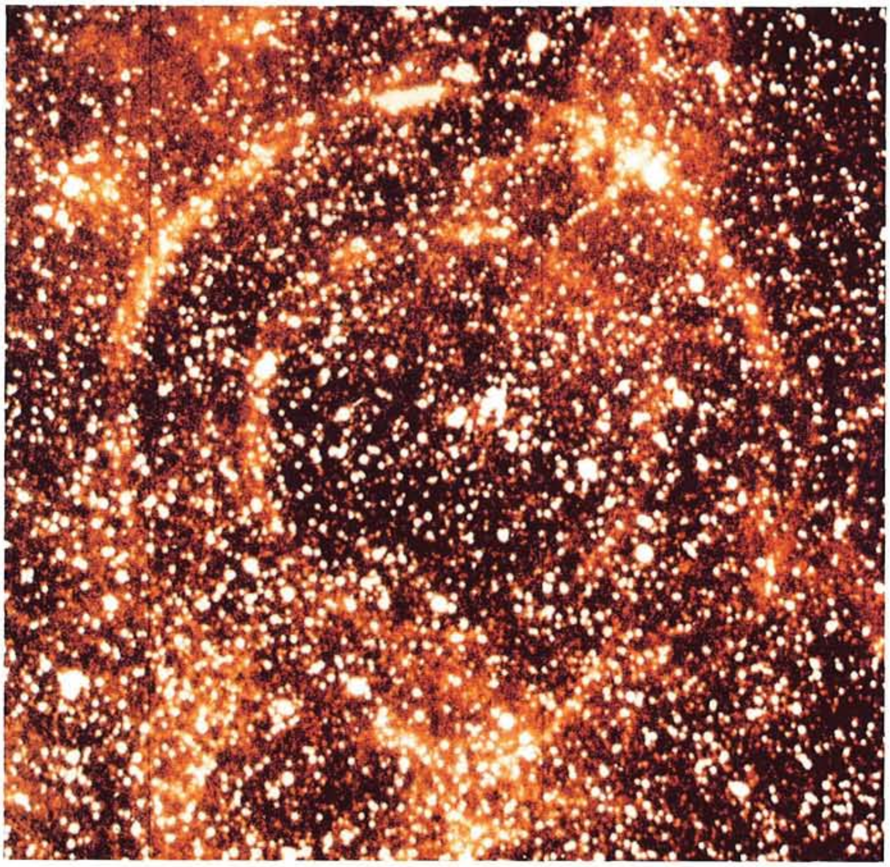

Figure 1: *CCD image from the NTT telescope + EMMI, 665.93nm, 6.6 nm filter, 20-min. exposure, taken on January 17, 1992.*

It is still not certain whether this arc can be related with the early evolution of the progenitor star of the supernova SN 1987A whose winds are believed to have produced interstellar bubbles of size around 50 pc (cf. Ref. 2). An answer to this question depends upon further investigations of chemical abundance and in particular velocity structure of this arc.

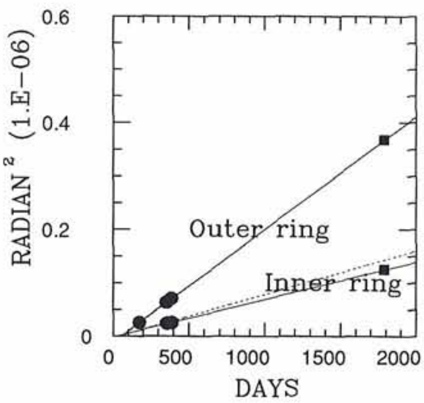

Figure 2: *Expansion diagram, solid circles are from Gouiffes et al. (1988), the squares are from Figure 1. Dotted lines represent fits given by Gouiffes et al. (1988), and the solid lines are fits after taking into account the new points.*

References

1. Gouiffes, C., Rosa, M., Melnick, J., Danziger, I.J., Remy, M., Santini, C., Sauvageot, J.L., Jakobson, P., and Ruiz, M.T. *Astron. Astroph.* **198**, L9–L12 (1988).
2. Chevalier R.A. and Emmering, R.T. *Astrophys. J.* **342**, L75–L78 (1989).

Observations of the Symbiotic Star BD –21°3873 within the Long-Term Photometry of Variables Programme

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1. Background

It is a well-known problem that the concentration of astronomical observations at a small number of large observatories together with the Visiting Astronomer system, resulting in the allotment of small parcels of observing time to individual astronomers and large gaps in between, makes the continuous monitoring of variable stars very difficult. Many stars with variations on time scales of weeks and months cannot be studied well in this mode. Therefore, ten years ago a group of astronomers convened on invitation of C. Sterken at the Astrofysisch Instituut of the Vrije Universiteit Brussel in order to discuss ways to overcome this problem. With the support of ESO these efforts resulted in the ongoing programme "Long-Term Photometry of Variables" (LTPV).

This joint programme involves various working groups from several ESO member countries and from Chile. It may be regarded as a prototype of an ESO Key Programme although it was initiated long before this term was invented. According to well-defined rules, a limited number of variable stars (distributed into 9 different groups according to the type of variability) are observed within this programme in the Strømgren photometric system every few days (intervals varying according to priority and requirements of the particular stars) at one of the smaller telescopes at La Silla (in recent years exclusively at the Danish 50-cm telescope) for usually 3 or 4 months per application period. In this way, a more or less continuous (apart from seasonal gaps) monitoring of the variable stars over a long time base is achieved. For a detailed description of the LTPV programme and its history, see Sterken (1983) and Wolf et al. (1987).

Here, we will report about results concerning a star of LTPV group 3. This group contains mainly – but not exclusively – either confirmed eclipsing binaries or stars where eclipses have been suspected. Moreover, some symbiotic stars which may or may not undergo eclipses are included in this group as well as some systems which exhibit(ed) variations of unidentified character. The particular star to be presented in this contribution is BD –21°3873, a yellow symbiotic star.

2. The Light Curve

Little is known about BD –21°3873. Bidelman and MacConnel (1973) observed hydrogen and He II 4686 Å emission lines in its spectrum, and Allen (1979, 1984) included the object into his list of symbiotic stars. Absorption lines indicate a spectral type of approximately G8 (Schulte-Ladbeck, 1988). BD –21°3873 may therefore belong to the ill-defined group of yellow symbiotic stars (Allen, 1988).

The star had a low priority in the LTPV programme and therefore only 25 measurements are available for an analysis. They span a time base of 1671 days. In spite of the few data points, a periodogram analysis revealed a well-defined period of 283 days. The yellow light curve of BD –21°3873, folded on this period, is shown in Figure 1. It has a roughly sinusoidal shape with two minima of about equal depth and two maxima, one of which is not well covered.

The light curve alone does not allow to distinguish between the proposed period of 283 days or one with half this value. This, however, is possible with the help of the colour curves. Figure 2 shows $b - y$ (upper frame), m_1 (central frame) and c_1 (lower frame) as a function of orbital phase. They all show a more or less sinusoidal shape with only one maximum and minimum per 283-day period. Whereas the amplitude of the $b - y$ curve remains small ($\approx 0^{m}.1$), the m_1 index already reaches an amplitude of $\approx 0^{m}.2$, and c_1 varies by a staggering amount of more than 1^{m}.

Regarding only the light curve, two interpretations for the basic mechanism of the variations appear viable: Stellar pulsations with a period of 141.5 days or ellipsoidal variations of a deformed star in a binary orbit of 283 days period. Clearly, the colour curves rule out the first alternative.

In addition to the photometric data we obtained a few spectrograms of BD–21°3873 at the ESO 1.52-m telescope, using the B & C spectrograph and a CCD. In Figure 3 we display one of them which refers to photometric phase 0.64. These observations confirm the earlier classification: The spectrum shows prominent emission lines of H, He I and He II superposed upon an absorption-line spectrum which we classify as a type G8 and (most probably) of luminosity class III.

There are reasons to believe that we see the light of at least two components in BD–21°3873. The ellipsoidal variations in the yellow light curve indicate the strong contribution of the G8 star which also dominates the optical spectrum. However, the colour indices (mean values and total ranges are given in Table 1) have values totally different from those encountered in normal (single) stars. They are probably influenced by the superposed emission lines and the free-bound continuum of a nebula.

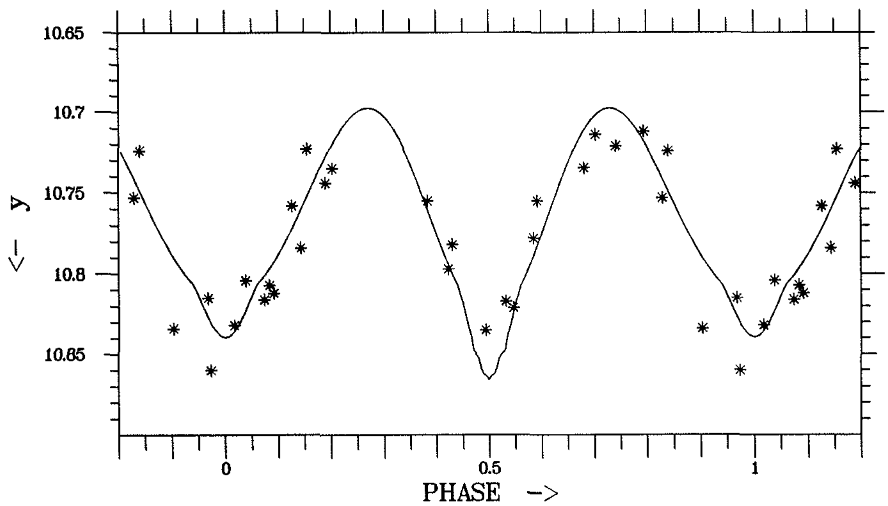

Figure 1: *The yellow light curve of BD–21°3873 folded on the period of 283 days. The superposed solid line is the best fit according to the Wilson-Devinney model. Grazing eclipses are indicated, while most of the variability is caused by ellipsoidal variations of the primary component.*

Table 1: *Mean values and ranges of colour indices*

Index	Mean	Range
$b - y$	0.952	0.905 ... 1.005
m_1	0.296	0.195 ... 0.416
c_1	−0.514	−1.070 ... 0.053

3. A Qualitative Model

The light curve together with the c_1 curve and its particularly strong variation suggests a simple qualitative model for BD−21°3873. For most of the period, c_1 is negative, reaching even values of < -1. Since this index measures the Balmer discontinuity, a strong Balmer continuum emission is probably responsible. In fact, the spectrum shown by Allen (1984) reveals a strong Balmer jump in emission. It has its origin in the gaseous emission region which is usually present in symbiotic stars. We suppose it to be centred on a small star or a compact object (to which we will refer as the primary hereafter, following the nomenclature normally used with respect to symbiotic stars) orbiting a giant of spectral type G (the secondary) which fills a considerable fraction of its Roche lobe, giving rise to the ellipsoidal variations.

The minimum of the c_1 index is observed when the emission region is best visible and contributes most to the total light of the system. It coincides in phase with one of the minima of the yellow light curve. This may be interpreted as being the phase of the lower conjunction of the primary (together with the emission region) and the secondary. The maximum value of c_1 then occurs at the phase of the upper conjunction when a part of the emission-line region is hidden behind the G star. Since the c_1 curve is approximately sinusoidal and no well-defined eclipse of the emission region is indicated in the c_1 index, it is supposed that the emitting gas is not confined to the region immediately around the primary on which it is centred, but that it envelopes the entire binary system.

4. A First Quantitative Test

Despite the fact that this is only a naive qualitative scenario, it appears to be able to explain the basic observations. Of course, it has to be subjected to a quantitative investigation. As a first step in this direction, and in order to learn more if not about reliable values for basic system parameters, but at least about orders of magnitude, we performed some preliminary model calculations.

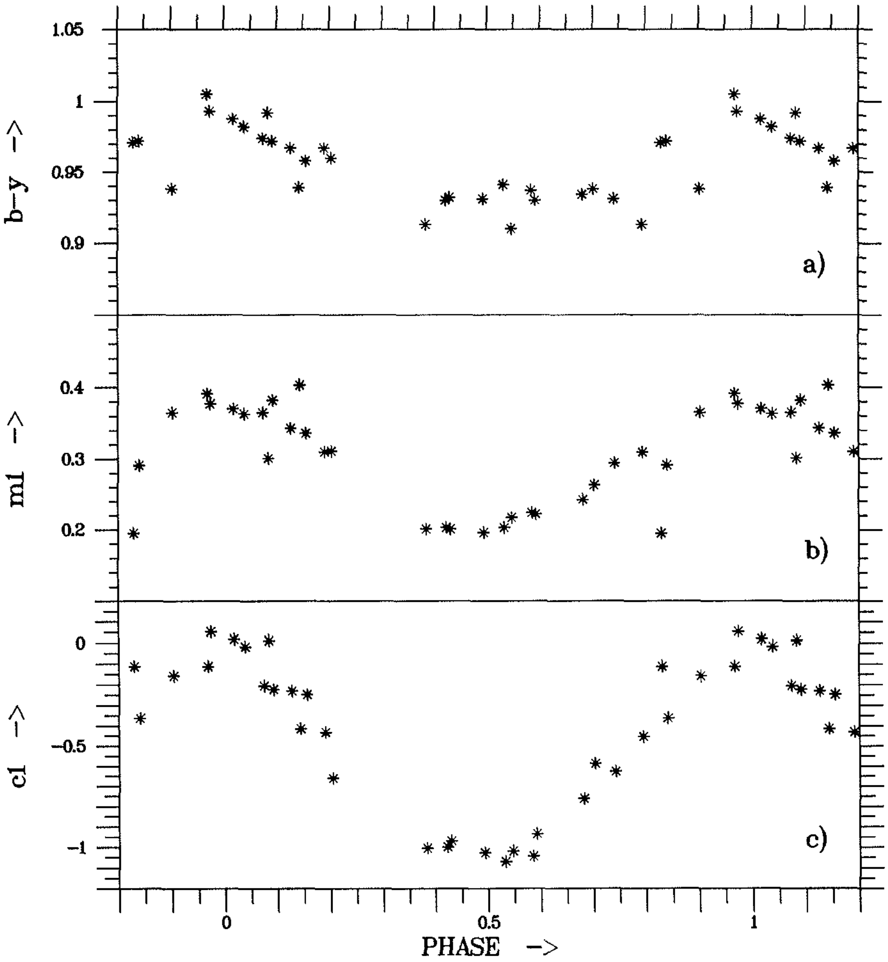

Figure 2: *Colour curves* b − y *(a),* m_1 *(b) and* c_1 *(c) of BD−21°3873, folded on the period of 283 days. In contrast to the light curve, the colour curves show only one maximum per cycle. Note the staggering amplitude of the variations of the* c_1 *index.*

We combined Wilson and Devinney's (1971) code for the calculation of light curves of binary systems with the simplex algorithm (Nelder and Mead, 1965), in order to automatically determine a set of system parameters which leads to an optimized fit of the calculated light curve to the observed data.

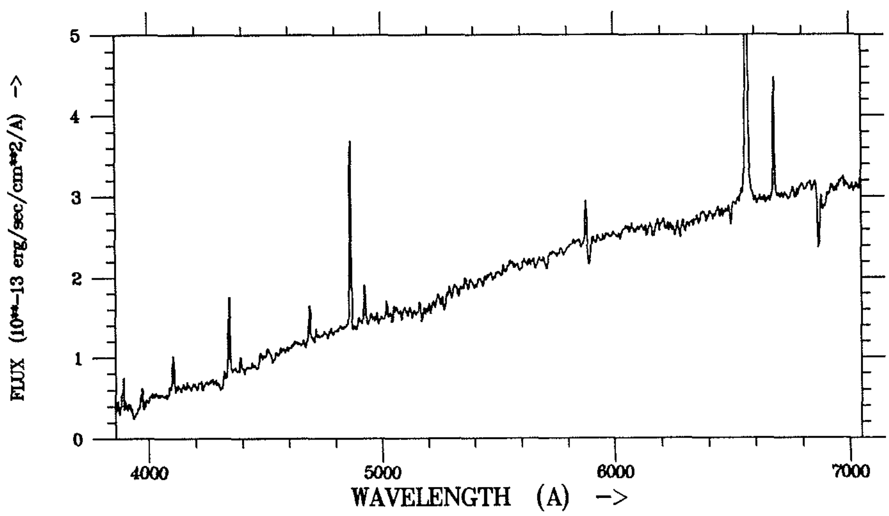

Figure 3: *A low-resolution spectrum of BD−21°3873 observed on February 24, 1988, with the ESO 1.52-m telescope, B & C spectrograph, and a CCD at photometric phase 0.64. Emission lines of H, HeI and HeII are superimposed on a reddened G8III spectrum. The truncated Hα line reaches a maximum flux of 13 × 10^{-13} erg/(sec cm² Å).*

We are aware that the Wilson-Devinney model cannot well describe a symbiotic binary since it supposes the stars to have a well-defined surface. Thus, it cannot handle the gaseous nebula. However, if the light of the system is dominated by the cool secondary (which can be treated as a normal star), a reasonable agreement between the calculated and the observed light curve may be found with parameters for the dominating star which are not altogether wrong. We therefore restrict our calculations to the *b* and *y* band data. It is then in fact possible to obtain a satisfactory fit. The calculated *y* light curve is shown in Figure 1 superposed upon the observed data points. The suspicion that the Wilson-Devinney model cannot be applied to data in spectral bands where the secondary does not dominate was confirmed by test calculations for the *u* and *v* bands. Here, a satisfactory fit proved not to be possible.

When performing a light curve fit it is advisable to fix as many free parameters as possible to values determined otherwise or to plausible ones, in order to relieve problems arising from correlations between them and to increase the reliability of the remaining parameters. In the present case we fixed the period to 283 days and the primary star temperature to 5000 K, appropriate for a late G-type star. Furthermore, we assumed the orbital eccentricity to be 0, the albedos of both components to be 1 and the gravity darkening parameter of the primary to be 0.32.

The results of a simultaneous fit to the *b* and *y* light curves are given in Table 2.

Here, *i* is the orbital inclination, T_1 the temperature of the primary, *q* the mass ratio defined as mass of secondary to primary, *L* the monochromatic luminosity, and Ω the dimensionless surface potentials. Ω_c is the potential of the Roche limit. σ is the standard deviation of the observed data points from the fitted ones.

It turns out that the light curve calculated with these parameters reproduces the observed one well. The G star is close to filling its Roche lobe as indicated by a comparison between its surface potential and the potential of the Roche limit. The system is seen under an angle where grazing eclipses of the primary are to be expected. For reasons outlined above, the parameters of the latter are, of course, unreliable.

It must be emphasized that these results are only preliminary. However, they confirm that the simple heuristic model outlined above is not altogether wrong and may serve as a starting point for more detailed investigations.

The long-term observations of BD −21°3873, although they could yield only few data so far, have thus already provided some interesting results. A further analysis of the available data and a more complete coverage of the light curve will certainly lead to a better understanding of the system. We therefore changed the priority of BD −21°3873 within the LTPV programme and gave it the highest weight within group 3. We hope that it will also be possible to obtain spectroscopic observations of the star around the orbit, although at a period of 283 days this will not be easy for someone who can only observe as a Visiting Astronomer and has no constant access to suitable observing facilities.

Table 2: *Best fit model parameters for BD −21°3873*

	b	*y*
i	68°	
T_1(K)	20100	
q	1.8	
Ω_1	10.7	
Ω_2	5.2	
Ω_c	5.0	
$L_2/(L_1 + L_2)$	0.835	0.968
σ (mag)	0.026	0.024

References

Allen, D.A.: 1979, in: F.M. Bateson, J. Smak, I.H. Urch (eds.): *Changing Trends in Variable Star Research,* Proc. IAU Coll. 46, p. 125.

Allen, D.A.: 1984, Proc. Astron. Soc. Australia, **5**, 369.

Allen, D.A.: 1988, in: J. Mikolajewska, M. Friedjung, S.J. Kenyon, R. Viotti (eds.): *The Symbiotic Phenomenon,* Proc. IAU Coll. 103, p. 3.

Bidelman, W.P., MacConnell, D.J.: 1973, *Astrophys. J.* **78**, 687.

Nelder, J.A., Mead, R.; 1965, *Computer Journal* **7**, 308.

Schulte-Ladbeck, R.E.: 1988, *Astron. Astrophys.* **189**, 97.

Sterken, C.: 1983, *The Messenger* **33**, 10.

Wilson, R.E., Devinney, E.J.: 1971, *Astrophys. J.* **166**, 605.

Wolf, B., Sterken, C., Stahl, O., Manfroid, J.: 1987, *The Messenger* **47**, 10.

The Importance of Lithium

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Recent developments increasingly emphasize the importance of lithium. Its primordial abundance is well known to severely constrain the nucleon density in the Universe (Kawano, 1988); it is now thought to be the first observational test to try to discriminate between non-standard cosmological models, such as the inhomogeneous ones inspired from the quark-hadron transition (Reeves, 1988).

Actually, the use of lithium as a cosmological barometer encounters a major obstacle: the uncertainty in the determination of its primordial abundance. Spite and Spite (1982) suggest that the constancy in the observed values of the ^{7}Li abundance toward very metal-deficient stars (Pop II) represents its primordial abundance, Log(Li/H) = −9.5 ± 0.2. In the interstellar medium and towards Pop I stars, the derived value is Log(Li/H) = −8.9 ± 0.2. If the Pop II value is typical of the primordial one (which seems to be the case, see Vangioni-Flam et al., 1989), then the explanation for a higher Pop I value becomes a crucial astrophysical issue. Furthermore, it appears that this value is slightly lower than the one measured in the solar system, derived from meteoritic measurements.

Lastly, the ^{7}Li abundance seems to be still increasing, for in the very young stars of the T Taurus molecular cloud, the abundance observed is on the average twice the Pop I value. The lithium evolution models have then to account for this galactic enrichment in ^{7}Li. Amongst them, it was suggested that ^{7}Li was produced by a slow mass-loss process in certain red giant stars (Scalo, 1976), in nova bursts under certain chemical conditions (Starrfield et al., 1978), and recently in supernova shocks (Dearborn et al., 1989).

While the red giant and nova models lead to an overproduction of ^{7}Li, the supernova process would account for the galactic enrichment in ^{7}Li and ^{11}B, two unresolved problems within the spallation scenario. Furthermore, it could explain the large difference between the meteoritic isotopic ratio ^{7}Li/^{6}Li = 12.5 and the only published value of the interstellar isotopic ratio : 38 (≥ 25) towards ς Ophiuchi (Ferlet and Dennefeld, 1984) by enrichment from a recent supernova within the Sco-Cen OB association. If confirmed, this model might reject some models of primordial nucleosynthesis, especially those trying to accommodate a high value (=1) of the baryonic density and inspired from the quark-hadron transition for the prediction of primordial ^{7}Li abundances up to Log(Li/H)= −0.7.

This clearly shows the importance of deriving a precise value for the interstellar lithium isotopic ratio along several lines of sight. It would permit to test the different models of galactic production and depletion of lithium, improve the knowledge of the chemical evolution of the Galaxy, and as well help to determine the ^{7}Li primordial abundance. However, as lithium is not very abundant in the interstellar clouds, the observed lines are extremely weak. The equivalent width is about 0.7 mÅ towards ς Oph, which is located behind a large diffuse cloud. Moreover, the stronger ^{6}Li line is blended with the weaker ^{7}Li line: the ^{7}Li line structure is a doublet at 6707.761-6707.912 Å, while ^{6}Li has the same structure red-shifted by 0.160 Å. Then, to measure the isotopic ratio, we have to derive the ^{6}Li abundance from its weaker line. According to the meteoritic ratio and the oscillator strengths, it is at least 25 times weaker than the stronger ^{7}Li line, i.e. an equivalent width of about 0.028 mÅ towards ς Oph!

Observations at the 3.6-m + Fibre Link to CES

The purpose of our investigation of interstellar lithium is to determine precisely the abundance of lithium along different lines of sight, here ϱ Oph, using the ESO 3.6-m Telescope linked to CES via fibre optics. This complex instrumentation is necessary to obtain a very high resolution ($\lambda/\Delta\lambda$ = 10^5), together with a signal-to-noise ratio as high as possible, in a still reasonable integration time. We determined a faint limit V~4 with the CAT+CES at this resolution for the S/N needed, showing that the 3.6-m is mandatory for such observations. We report here on five nights in June 1990 and July 1991.

We used the ESO General Fiber Optics (GFO) optic fibre connected at the Cassegrain focus of the 3.6-m telescope with an entrance slit width of 3."4 on the sky. At the output end the image is projected on an image slicer, which produces 11 slices and aligns them on the entrance slit of the CES predisperser; this allows a better signal-to noise ratio without saturating the CCD. The CES is operated in the Long Camera mode at a resolving power of 100,000 at 6708 Å, giving a reciprocal dispersion of 1.88 mm Å or 0.028 Å per pixel, i.e. a resolution element of 67 mÅ or 2.2 pixels. We used the ESO CCD detector #9 of 1024×640 pixels with a responsive quantum efficiency of 75% at 6708 Å and a gain of 7.4 e^-/pix. The internal transmission of the optic fibre has a maximum at 8000 Å, being 95% at 6708 Å. The overall efficiency of the 3.6-m + fibre link + CES instrumentation allows a gain of 1.65 magnitudes at this wavelength, as compared to the CAT + CES (Avila and D'Odorico, 1988). In practice, at 6708 Å and under normal seeing conditions, about 30 min are required to obtain a signal-to-noise ratio of 700 for a star of magnitude 5.0.

The observed star, ϱ Oph, was chosen to be observed in June 1990 because it is reasonably bright (V = 5.0), its spectrum is featureless in the Li region (spectral type B2IV), it has a large reddening (E(B-V)=0.47) and a total hydrogen column density along the line of sight N(H)=72.10^{20} cm^{-2}, which proves the presence of very dense, diffuse interstellar clouds.

The observations revealed a very strong lithium absorption line, about 3 times stronger than towards ς Oph, making ϱ Oph the best candidate up to now for evaluating the interstellar lithium isotopic ratio. In July 1991, we made exposures of 1 hour each, because of the magnitude of ϱ Oph, and to avoid too many cosmic events. Indeed, the use of an image slicer broadens considerably the signal over the CCD perpendicularly to the dispersion, thus increasing the number of detected cosmic events. These events can however be easily removed before summing. The central wavelength was shifted slightly from one night to the other to identify possible systematic effects due for instance to bad pixels.

Each spectrum was reduced individually using the IHAP software at IAP in the following way:

– subtraction of the *bias*, i.e. the readout noise of the CCD, measured at different intervals to check possible variations; the dark current, or thermal leakage, very weak (2.5 e/h/pix), was taken into account;

– division by the response curve of the CCD to the spectra of a very bright star not showing any stellar or interstellar absorption in the wavelength range, here α Aql or β Cen. About 25 exposures per night of such flat-field exposures were done very close in time to the exposures of ϱ Oph. We experienced that this improves the signal to noise as the response curve to this flat-field star is much more similar to the observation itself than a flat-field lamp, especially with respect to the well-known problem of fringes; and

– we then averaged the signal over all of the CCD. Here the slices to be added were the central ones, where the signal between two consecutive slices is still important as compared to the noise level. The spectra were then combined taking into account all the revelant wawelength shifts as well as the heliocentric velocity correction for each exposure. The wavelength calibration is based on a thorium-argon lamp, observed several times throughout the night to check for possible variations. We found that the CES was stable within one pixel, i.e. 1.2 km/s; the internal accuracy is ~ 7 mÅ.

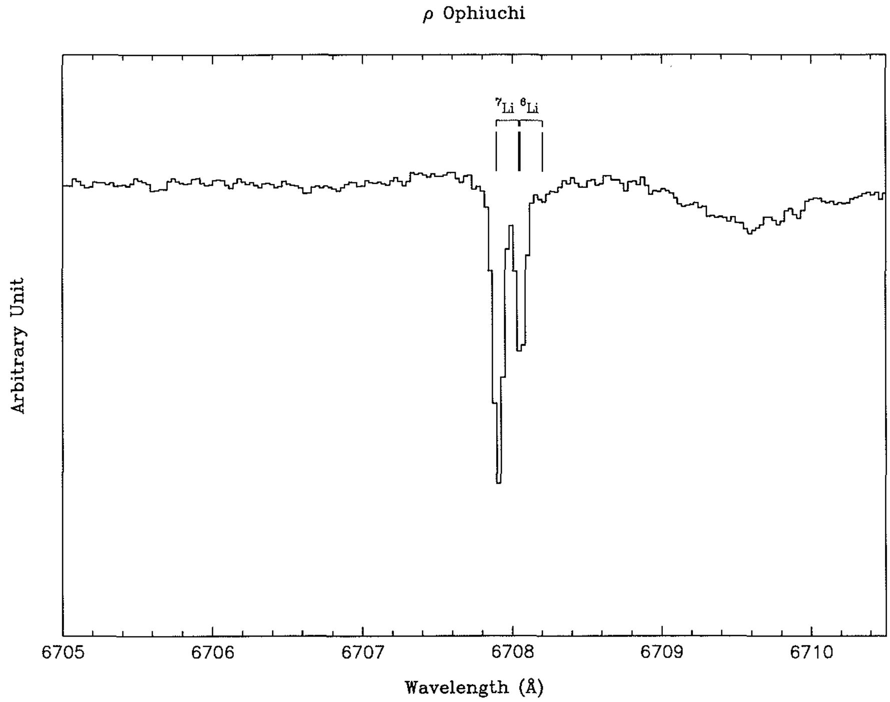
The spectrum shown in the figure on page 42 (enlarged in the Li region) represents a total integration time of 13 hours. The signal-to-noise ratio is about 2700 and the equivalent width for the total Li I lines is 2.1 mÅ. We measured this S/N on the blue side of the Li lines by dividing the mean signal by the root mean square noise (*rms*). There is a broad unidentified feature on the red side of the lines that possibly corresponds to the absorption by a diffuse interstellar band; this feature, near 6709.5 Å, is also seen towards all other stars observed in Li I.

The identification of the ^{7}Li lines is unquestionable; the interstellar heliocentric velocity is found to be −8.5 km/s, in very good agreement with the previous observations of ϱ Oph in Ca II-K and Na I-D lines (Hobbs, 1975: K-line at −7.3 km/s, D-line at −8.9 km/s). However, the detection of the weaker ^{6}Li line is questionable since the corresponding feature on the spectrum is only 1σ deep, and does not allow a precise measurement of its position. Still, we can estimate an upper limit for its equivalent width, hence a lower limit for the isotopic ratio. Indeed, at this wavelength, with the present resolution (R=100,000) and signal-to-noise ratio (S/N=2700), the limiting detectable equivalent width is 0.050 mÅ for a 2σ detection. Considering the total equivalent width for the Li I lines, this yields ^{7}Li/^{6}Li≥13. This evaluation, although compatible with the solar system value, seems to favour a higher isotopic ratio, in possible confirmation of the only other measurement made towards ς Oph: ^{7}Li/^{6}Li=38 (≥25). We estimate that a total integration time of 50 hours is needed with this instrumental configuration to confirm or not at 2σ this detection of the weaker ^{6}Li component.

Further speculations on this spectrum are still premature. Only a detailed analysis with the profile fitting method developed by Vidal-Madjar et al. (1977) and Ferlet et al. (1980 a, b) may help to evaluate with precision the interstellar lithium isotopic ratio. This method was already applied to the interstellar Li lines towards ς Oph by Ferlet and Dennefeld (1984), yielding the above-mentioned result. It offers the possibility of extracting all the information contained in the profile, particularly the velocity structure along the line of sight (previous articles indicate the presence of two components), and allows calculation of the blend between the isotopes lines. This will be the scope of a forthcoming paper on the present data.

While the study of the interstellar lithium isotopic ratio is of crucial importance for nucleosynthesis and chemical evolution, it is certainly not an easy task. The observation of extremely weak interstellar lithium lines towards relatively faint star requires a very efficient instrumentation. The 3.6-m + CES via fiber link fulfils this quite well, as can be judged by the quality of the present data, provided great care is taken during the observations and data reduction.

Moreover, observations in July 1991 with the CAT revealed new good candidates for the interstellar lithium ratio, especially ο Sco, and χ Oph, which were observed for the first time at this wavelength. Their total Li equivalent width have not been precisely estimated yet, but we hope to investigate these new lines of sight. We will also continue to accumulate photons from ϱ Oph to further improve the S/N in order to definitely detect the weakest ^{6}Li line. Still, the perspective of the VLT brings new hope for this difficult task; it should even allow measurements of the abundance of lithium in the Magellanic Clouds.



Acknowledgements

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References

Avila, G., D'Odorico, S.: 1988, Proceedings of the ESO Conference on Very Large Telescopes and their Instrumentation, Garching, 21-24 March 1988, p. 1121.

Dearborn, D., Schramm, D., Steigman, G., Truran, J.: 1989, *Astrophys. J.*, **347**, 455.

Ferlet, R., Laurent, C., Vidal-Madjar, A., York, D.G.: 1980a, *Astrophys. J.*, **235**, 478.

Ferlet, R., Vidal-Madjar, A., Laurent, C., York, D.G.: 1980b, *Astrophys. J.*, **242**, 576.

Ferlet, R., Dennefeld, M.: 1984, *Astron. Astrophys.*, **138**, 203.

Kawano, A.: 1988, *Astrophys. J. Letters*, **327**, L750.

Hobbs, L.M.: 1975, *Astrophys. J.*, **200**, 621.

Hobbs, L.M., Pilachowski, C.: 1988, *Astrophys. J.*, **334**, 750.

Reeves, H.: 1988, *European Journal of Physics*, **9**, 179.

Scalo, J.M.: 1976, *Astrophys. J.*, **206**, 795.

Spite, F., Spite, M.: 1982, *Astron. Astrophys.*, **115**, 357.

Starrfield, S., Truran, J.W., Sparks, W.M., Arnould, M.: 1978, *Astrophys. J.*, **222**, 600.

Vangioni-Flam, E., Casse, M., Oberto, Y.: 1989, *Astrophys. J.*, **349**, 510.

Vidal-Madjar, A., Laurent, C., Bonnet, R.M., York, D.G.: 1977, *Astrophys. J.*, **211**, 91.

On Flux Calibration of Spectra

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1. Introduction

In an *A&A* paper on spectroscopic reduction, two spectral correction functions for the spectral range 375 < λ[nm] < 900 were derived (Fluks and Thé, 1992). The first $\chi_e(\lambda)$, accounts for the depletion of stellar radiation in the Earth's atmosphere and the second, $\chi_s(\lambda)$, for the blocking of part of the radiation by the spectrograph slit. In the present paper we summarize the main results for those observers who are interested in our method but not in the mathematical part of the problem.

The atmospheric scattering and molecular absorption at ESO is given in Table 1, and using Table 3, one can correct for the blocking of part of the radiation by the spectrograph slit. We derived formulas for two slit positions: in the west-east direction in the horizontal plane and in the hour angle declination in the elevated plane. By applying our method, the spectral flux-calibration will be more accurate.

In the three (artificial) wavelength-calibrated spectra, shown in Figure 1, $f_1(\lambda)$ is the spectrum before entering the atmosphere ($:= F(\lambda)\chi_{resp}(\lambda)$, in which $F(\lambda)$ is the flux-calibrated spectrum and $\chi_{resp}(\lambda)$ is the instrumental response function), $f_2(\lambda)$ is the spectrum after its passage through the atmosphere and $f_3(\lambda)$ is the "observed" CCD spectrum.

$\chi_e(\lambda) = \chi_{sc}(\lambda)\chi_a(\lambda)$ is the spectral transparency function of the atmosphere in which $\chi_{sc}(\lambda)$ accounts for the scattering (Aerosol scattering and Rayleigh scat-

Table 1 A: *The continuous spectral scattering and absorption of the Earth's atmosphere at ESO at z = 0°.*

λ [nm]	a_e (λ) [mag]	a_a (λ) [mag]	λ [nm]	a_e (λ) [mag]	a_a (λ) [mag]	λ [nm]	a_e (λ) [mag]	a_a (λ) [mag]
375.0	0.3849	0.0000	720.0	0.0403	0.0758	764.0	0.0348	0.3495
400.0	0.2900	0.0000	730.0	0.0388	0.0753	765.0	0.0345	0.2610
450.0	0.1805	0.0000	740.0	0.0373	0.0163	767.5	0.0342	0.1245
475.0	0.1517	0.0020	750.0	0.0365	0.0000	770.0	0.0340	0.0557
500.0	0.1324	0.0065	757.0	0.0356	0.0017	772.5	0.0335	0.0219
525.0	0.1155	0.0120	757.5	0.0355	0.0035	774.0	0.0333	0.0054
550.0	0.1010	0.0207	758.0	0.0355	0.0071	775.0	0.0332	0.0000
580.0	0.0859	0.0269	758.5	0.0355	0.0167	780.0	0.0325	0.0000
600.0	0.0762	0.0178	759.0	0.0354	0.0478	799.0	0.0298	0.0013
625.0	0.0650	0.0112	759.2	0.0354	0.1370	800.0	0.0297	0.0038
650.0	0.0548	0.0066	759.5	0.0353	0.4101	801.0	0.0295	0.0067
675.0	0.0476	0.0026	760.0	0.0353	0.7422	802.0	0.0294	0.0098
685.0	0.0456	0.0093	760.2	0.0352	0.8410	805.0	0.0289	0.0205
686.0	0.0455	0.0317	760.5	0.0352	0.8983	810.0	0.0280	0.0519
687.0	0.0453	0.2198	760.6	0.0351	0.8749	815.0	0.0272	0.1181
687.1	0.0453	0.2173	760.8	0.0351	0.8039	820.0	0.0264	0.2350
687.5	0.0452	0.1648	761.0	0.0351	0.7283	821.0	0.0262	0.2484
688.0	0.0451	0.0614	761.4	0.0350	0.4327	821.5	0.0261	0.2504
688.2	0.0451	0.0202	761.8	0.0350	0.1994	822.0	0.0260	0.2484
688.5	0.0450	0.0737	761.9	0.0350	0.1923	825.0	0.0255	0.1818
689.0	0.0450	0.0986	762.0	0.0350	0.2212	830.0	0.0246	0.0850
690.0	0.0448	0.0715	762.4	0.0349	0.4539	835.0	0.0238	0.0370
691.0	0.0446	0.0553	762.6	0.0349	0.4939	840.0	0.0229	0.0128
695.0	0.0440	0.0225	762.8	0.0349	0.4800	850.0	0.0212	0.0000
700.0	0.0432	0.0176	763.0	0.0349	0.4621	875.0	0.0170	0.0000
710.0	0.0417	0.0334	763.5	0.0348	0.4060	900.0	0.0127	0.0000

Table 1 B: *The characteristics of the absorption bands (Kondratyev 1969).*

Denomination of band	Absorbing molecule	Spectral region [nm]	Band centre position [nm]
Chappuis	O_3	440 – 750	580
B	O_2	685 – 702	687
α	H_2O	700 – 740	718
A	O_2	758 – 775	760
0.8 μm	H_2O	800 – 843	821

tering) and $\chi_a(\lambda)$ for the molecular absorption bands (H_2O, O_2 and O_3).

If in the spectroscopic reduction the observed spectra of standard stars are not corrected for $\chi_e(\lambda)\chi_s(\lambda)$, the instrumental response function $\chi_{resp}(\lambda)$ deduced from these spectra will be biased by this factor. In this paper, the spectral functions $\chi_e(\lambda)$ and $\chi_s(\lambda)$ are removed from the instrumental response function $\chi_{resp}(\lambda)$ so that the $\chi_{resp}(\lambda)$, deduced from the observations of standard stars, becomes independent of the position of these stars.

2. The Spectral Transparency of the Earth's Atmosphere

Due to continuous atmospheric scattering and atmospheric molecular absorption, atmospheric features are superimposed onto those in stellar spectra. By normalizing the spectra of white dwarfs, having few or no intrinsic spectral features in the spectral regions of Table 1, the absorbing component $\chi_a(\lambda)$ of $\chi_e(\lambda)$ can be found. The slowly varying continuous functions $\chi_{sc}(\lambda)$ and $\chi_s(\lambda)$ resolve in the normalizing procedure, so that $\chi_a(\lambda)$ can be obtained from the observation: $\chi_a(\lambda) = \frac{f_3(\lambda)}{f_4(\lambda)}$ in which $f_4(\lambda)$ is the normalized spectrum of $f_3(\lambda)$ (see Fig. 2). Tüg (1977) gives the summation of the Aerosol scattering, the Rayleigh scattering and the absorption by ozone in magnitudes $a_e(\lambda)$ at zenith distance z=0° at ESO. Removing the ozone component from Tügs $a_e(\lambda)$ at z=45°, the corresponding continuous scattering component of the spectral transparency function, $\chi_{sc}(\lambda)$ is found. Next, $\chi_e(\lambda)$ at z=45° and at z=0° are obtained. These results are displayed in Figure 2 and Figure 3, respectively. Table 1A gives the spectral scattering and absorption of the Earth's atmosphere at ESO at z=0°, and Table 1B the denomination of the absorbing bands, the spectral region, and the band centre positions (Kondratyev, 1969). Note that the entries in Table 1A are still subject to nocturnal and annual variations (especially of H_2O). Other workers in spectroscopy might adjust the results of Table 1A to their own observational conditions.

Two sharply double-peaked oxygen absorption bands are encountered, centred at 687 and 760 nm, respectively. The two water vapour absorption bands centred at 718 and 821 nm are too weak and there is too much scatter in the normalized spectra to reveal the real structure inside these bands (there are subfeatures at 816.4, 817.7 and 822.7 nm). By replacing the MIDAS table ATMOEXAN, containing Tügs $a_e(\lambda)$, by NEWATMOEXAN, containing the $a_e(\lambda)$, obtained from Table 1A, stellar spectra can be corrected for atmospheric scattering plus absorption, at a specific airmass, using MIDAS routine EXTINCTION/SPECTRUM.

3. The Spectral Transmittance at the Spectrograph Slit

Light of either end of a stellar spectrum will be more lost compared to that at the centre, since the slit has finite

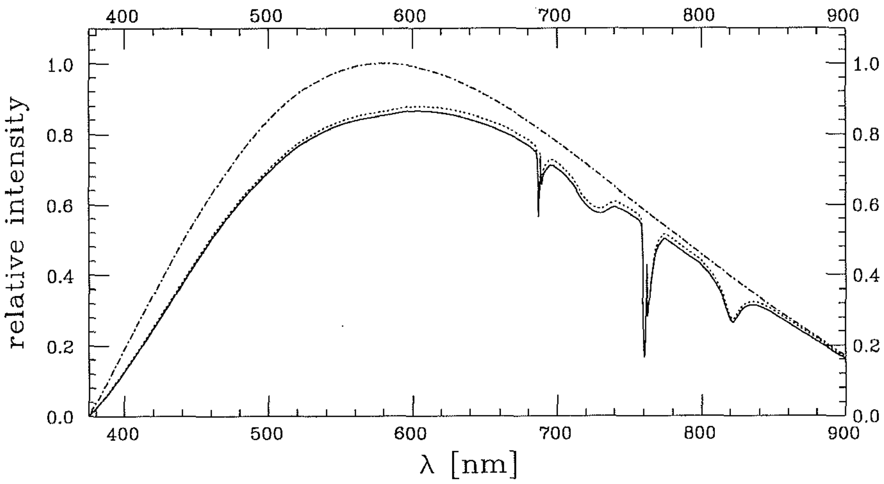


Figure 1: *Three wavelength-calibrated spectra: $f_1(\lambda)$ (dot-dashed curve), f_2 (λ) (dotted curve) and $f_3(\lambda)$ (solid curve) for a star at z = A = 45° with surface brightness dispersion σ = 0.″800 and a horizontal mounted spectrograph slit of sizes 2a × 2b = 5″ × 240″.*

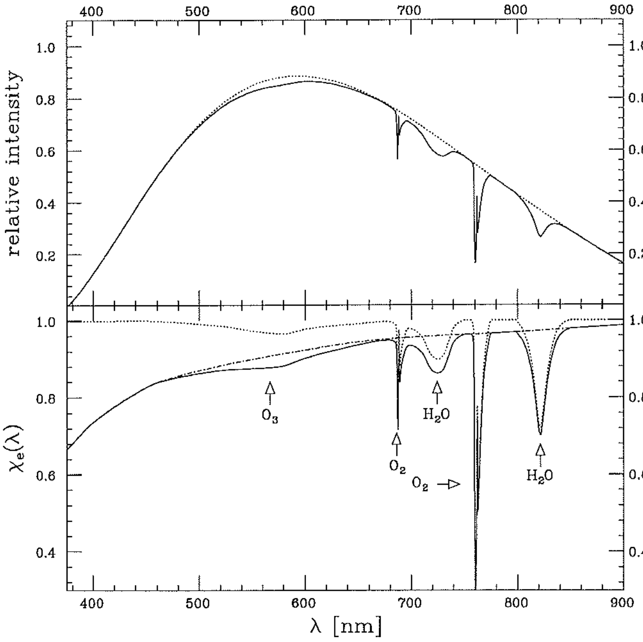


Figure 2: *The top frame shows the normalizing procedure. The solid curve is the "observed" spectrum f_3 (λ) and the dotted curve is its normalized wavelength-calibrated spectrum f_4 (λ) at z = 45°. In the bottom frame, the dotted curve is the absorbing component and the dot-dashed curve is the scattering component of χ_e (λ) (solid curve) at z = 45°.*

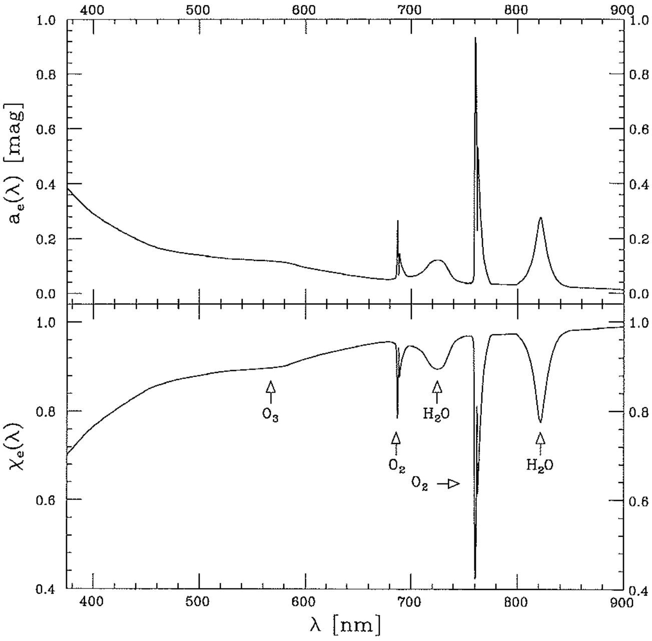


Figure 3: *The effects of Aerosol scattering, Rayleigh scattering and the atmospheric molecular absorption of H_2O, O_2 and O_3 upon stellar spectra at z = 0° at ESO. Top curve: a_e (λ); bottom curve: χ_e (λ).*

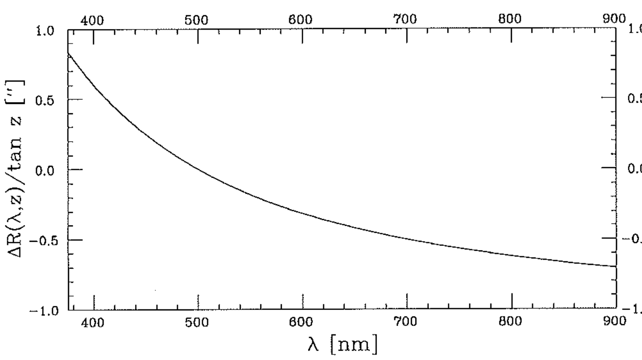


Figure 4: *The differential atmospheric refraction.*

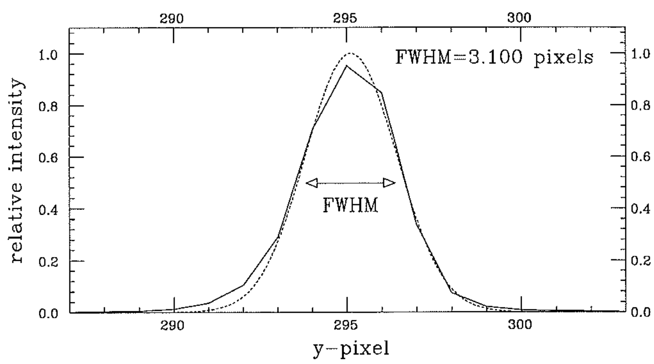


Figure 5: *The cross-section of a CCD image and its Gaussian approximation (dotted curve), produced by the MIDAS routine CENTER/GAUSS. FWHM is the full width at half maximum of the Gaussian.*

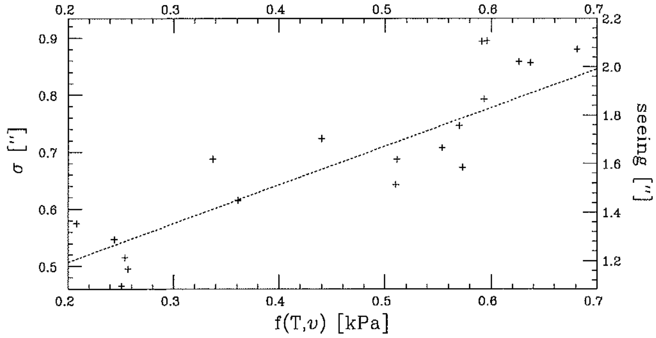


Figure 6: *The correlation between the dispersion (seeing) and the vapour pressure.*

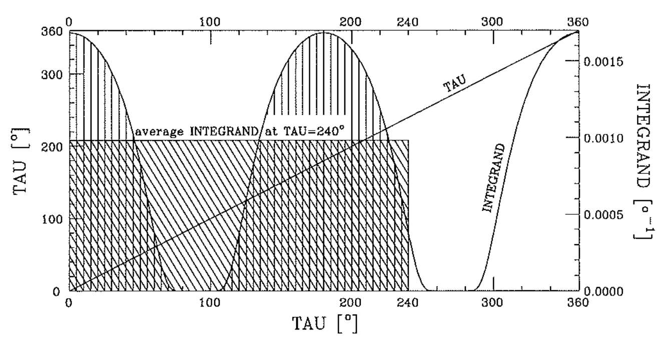


Figure 7: *Solving* $S_{B,\,C,\,\sigma}(\tau) = \frac{1}{2\pi} \int_0^{\tau} exp \left(\frac{-C^2}{2\sigma^2 (B^2+1) \cos^2 \tau} \right) d\tau$ *with MIDAS at* $\frac{C^2}{2\sigma^2 (B^2+1)}$ *= 0.5 and* τ *= 240°.*

Table 2: *The differential atmospheric mean refraction relative to 500 nm at ESO.*

λ [nm]	$\frac{\Delta R(\lambda, z)}{\tan z}$	λ [nm]	$\frac{\Delta R(\lambda, z)}{\tan z}$
375	0.″84	650	−0.″42
400	0.″60	700	−0.″50
450	0.″25	750	−0.″57
500	0.″00	800	−0.″62
550	−0.″18	850	−0.″67
600	−0.″32	900	−0.″70

dimensions and the extended stellar image cannot be simultaneously placed at the same position within the slit at all wavelengths (the star is assumed to be centred at 500 nm). The spectral transmittance function at the spectrograph slit $\chi_s(\lambda)$ is the fraction of stellar light that passes through the slit; the slit length 2b depends upon the telescope and the slit widths are chosen by the observer.

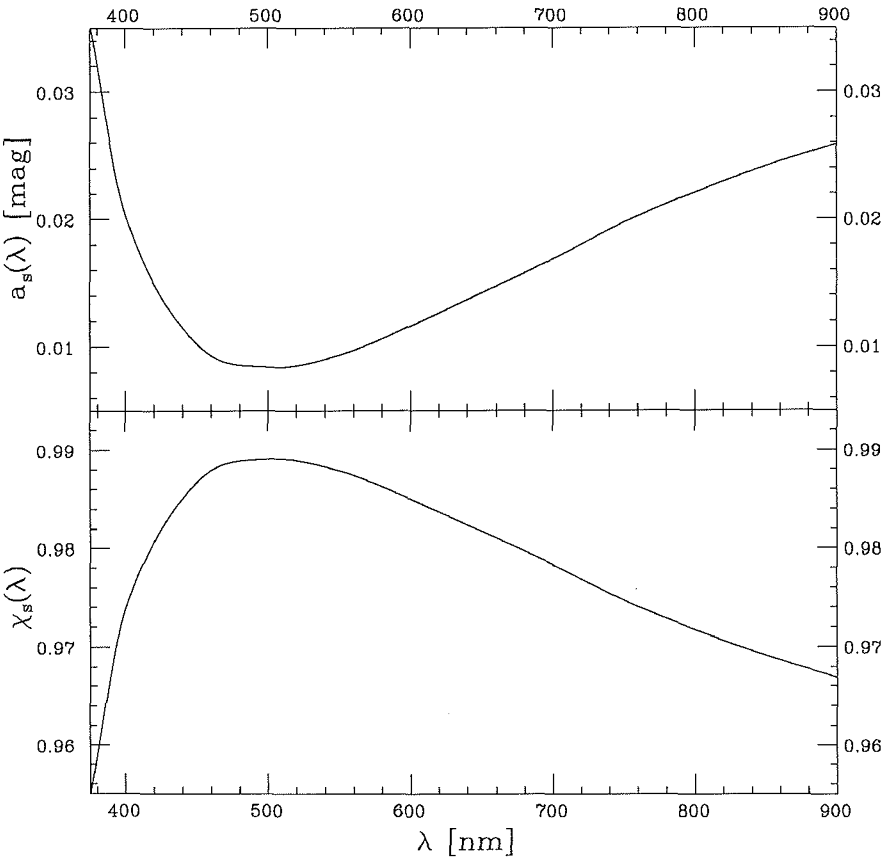


Figure 8: *The total effects of differential atmospheric refraction, finite spectrograph-slit dimensions and slit orientation upon a stellar spectrum for a star z = A = 45° with σ = 0.″800 and a horizontal mounted spectrograph-slit of sizes 2a × 2b = 5″ × 240″. Top curve: a_s (λ); bottom curve: χ_s (λ).*

3.1 Atmospheric optics

There are two atmospheric quantities to be solved: ΔR(λ, z), the differential atmospheric mean refraction relative to 500 *nm and* σ, *the* nocturnal dispersion (seeing) of the (Gaussian) surface brightness of the stellar image. We derived both quantities in the *A&A* paper from meteorological measurements at ESO; *in the present paper we* just present the results.

Due to the differential atmospheric refraction, a weakened spectrum enters the telescope and therefore, light of different λ experiences the spectrograph slit differently. The function $\frac{\Delta R(\lambda, z)}{\tan z}$ is plotted in Figure 4 and listed in Table 2.

Small-scale rapidly variable atmospheric turbulences cause a blowing up of stellar images. Our elaborations (Fluks and Thé, 1992) showed that σ is independent of λ and depends mainly upon the vapour pressure f(T, υ), a function of the temperature T and the relative *humidity* υ. This is shown in Figure 6; the datapoints on which the relation between f(T, υ) and σ is based, are also displayed. There is a link between this relation and the generalization of Brunt's *formula* (Kondratyev, 1969): *in* moist and/or warm turbulent air (high vapour pressure) the absorptivity and thus the re-emissivity of water vapour will be higher and therefore σ broader. The σs were obtained from the observed CCD intensity-profiles, like the one of Figure 5, and depends on the full width at half maximum (FWHM) and the spatial scale of the telescope.

Table 3: *MIDAS routines to obtain* $S_{B,\,C,\,\sigma}(\tau) = \frac{1}{2\pi} \int_0^{\tau} \exp\left(\frac{-C^2}{2\sigma^2 (B^2+1) \cos^2 \tau}\right) d\tau$.

STEP	ROUTINE
	Create variable TAU, 0° ≤ *TAU* ≤ 360° (to be executed just once):
Midas 001 >	CREATE/IMAGE TAU 1,10001 0,0.036
Midas 002 >	COPY/IT TAU TAU
Midas 003 >	COMPUTE/TABLE TAU :TAU = 0.036∗ (SEQ-1)
Midas 004 >	CONVERT/TABLE TAU =TAU :TAU :TAU TAU SPLINE
	Compute INTEGRAND:
Midas 005 >	COMPUTE/IMAGE INTEGRAND = COS(TAU)∗COS(TAU)/+
Midas 006 >	COMPUTE/IMAGE INTEGRAND = EXP (-1/INTEGRAND)/360
	Compute INTEGRAL:
Midas 007 >	AVERAGE/COLUMN INTEGRAL = INTEGRAND 0, ⧺
Midas 008 >	COMPUTE/IMAGE INTEGRAL = INTEGRAL∗⧺
Midas 009 >	FIND/MINIMAX INTEGRAL
	+: include value for $\frac{C^2}{2\sigma^2 (B^2+1)}$; ⧺: include value for τ, *error* ≲ 5 10^{-5}

3.2 The surface brightness

There are two ways to describe the transmittance problem. One can apply the fixed coordinates x and y or the wavelength-dependent coordinates u and v. In the {x, y}-system in the plane of the slit, the slit is a fixed rectangle and the surface brightness is ellipsoidal. In the {u, υ}-system in the elevated plane, the light experiences the slit as an off-centred parallelogram, the surface brightness is circular, and a numerical solution of $\chi_s(\lambda)$ can be found.

3.3 The solution

The key-equation for solving $\chi_s(\lambda)$ is,

$$\chi_s(\lambda) = 1 + \sum_{i=1}^{4} \left(S_{B,\,C,\,\sigma}(\tau_i) - S_{B,\,C,\,\sigma}(\tau_{i+1})\right) \leq 1$$

in which B, C and τ are amalgamations of astrometric, spectrographic, meteorological and optical variables and parameters. The index i refers to a particular part of the slit, determined by lines connecting the slit centre to the vertices. In the *A&A* paper, the solutions to B, C and τ are given.

In order to obtain $\chi_s(\lambda)$ one has to solve $S_{B,C,\sigma}(\tau)$,

$$S_{B,\,C,\,\sigma}\,(\tau) = \frac{1}{2\pi}\int_0^\tau \exp\left(\frac{-C^2}{2\sigma^2\,(B^2+1)\cos^2\tau}\right)d\tau$$

A serious complication in the numerical evaluation to $S_{B,C,\sigma}(\tau)$ is that the wavelength appears in τ.

Table 3 shows how MIDAS (release 90NOV) deals with such problems. First, the file TAU is created in 10,000 steps of 0°.036 each (10001 pixels), starting at 0°:0° ≤ TAU ≤ 360°. MIDAS treats the contents of a file (in this case the contents of the file TAU) as the input in its computations. As a consequence the file TAU itself, with its pixel values identical to the corresponding world-coordinates, can be considered as a variable. The result is shown in Figure 7 (referring to the left axis of this figure). In the second stage, MIDAS computes

$$\frac{1}{360}\exp\left(\frac{-C^2}{2\sigma^2\,(B^2+1)\cos^2\tau}\right),$$

named INTEGRAND. The result at

$$\frac{-C^2}{2\sigma^2\,(B^2+1)}$$

= 0.5 is also displayed in Figure 7 (referring to the right axis of this figure). In the third stage of Table 3 (the integration of INTEGRAND from 0° to 240°) MIDAS computes $S_{B,C,\sigma}(240°)$, named INTEGRAL, as the average of INTEGRAND in the interval 0° ≤ TAU ≤ 240 °, multiplied by the interval itself (thus the two hatched areas of Figure 7 cover identical surfaces). Note that $S_{B,C,\sigma}(\tau)$ uses radians whereas MIDAS computes in degrees.

Once the $\chi_s(\lambda)$s have been solved for the λs of Table 2, MIDAS produces $\chi_s(\lambda)$ for all λs by the interpolation-routine CONVERT/TABLE (see also Table 3). The results obtained using the above outlined procedure are displayed in Figure 8. From $\chi_s(\lambda)$, $a_s(\lambda)$ can then be obtained.

References

Cramer, N. June 1990, *The Messenger*, **60**, 62.

Filippenko, A. 1982, *PASP*, **94**, 715.

Fluks, M.A., and Thé, P.S. 1992, *A&A*, **255**, 477.

Kondratyev, K.YA. 1969, "Radiation in the atmosphere", International geophysics series, volume 12, Academic Press, Chapters 3 to 5.

Tüg, H. December 1977, *The Messenger*, **11**, 7.

Valley, S.L. (Ed.) 1965, "Handbook of geophysics and space environments", McGraw-Hill Book Company Inc., Chapters 7, 10 and 16.

A Coronagraph for COME-ON, the Adaptive Optics VLT Prototype

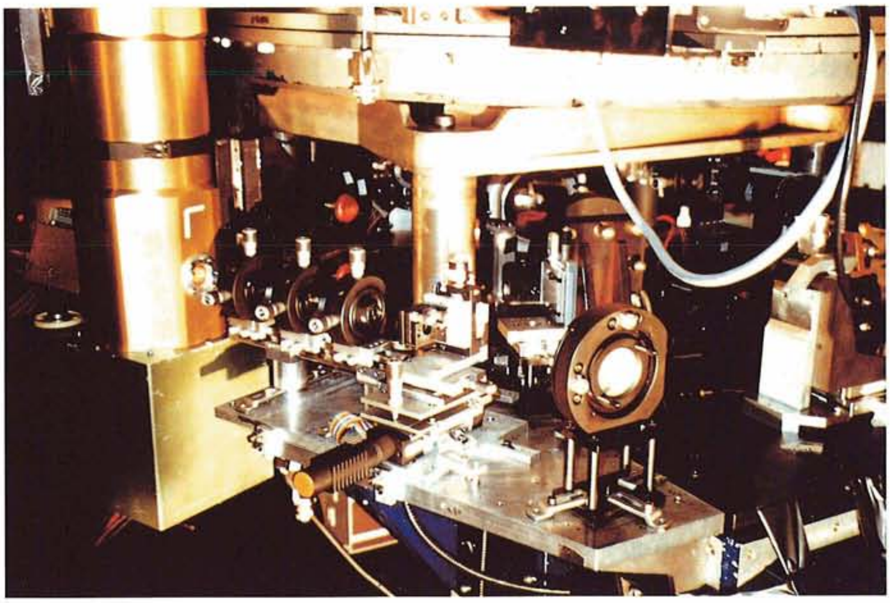
F. MALBET, Observatoire de Paris and Observatoire de Grenoble, France

Thanks to new adaptive optics systems, imaging resolution has reached the diffraction limit of large telescopes in the near-infrared. Numerous aspects of astronomy (spectroscopy, polarimetry,...) will benefit from this progress. Coronagraphic imaging belongs to this category. A coronagraph installed in an adaptive optics system will significantly increase the imaging contrast. In addition, adaptive optics yields stable images and this gives a high efficiency to the coronagraphic imaging. Up to now, an increase in spatial resolution meant a loss in coronagraphic efficiency, for the central star could almost never be exactly aligned with the occulting mask because of the seeing motion. For instance, the smallest mask used to observe the β Pictoris circumstellar disk had a diameter of 4.5 arcsec on the sky, corresponding to 30 AU. However, most of the essential and needed information lies inside this distance.

The coronagraph fitting the COME-ON adaptive optics system has been developed in 1990 in the Département de Recherche Spatiale, at the Observatoire de Paris (Meudon). It was originally designed to detect circumstellar environments around young stellar objects. The optical layout it simple; the coronagraph elements are inserted between the On-Off mirror and the infrared detector (see Fig. 1). The first lens L1 images the focal plane onto the mask M; the lens L2 then collimates the light onto the Lyot stop, which can be present or not; finally, the lens L3 reimages the focal plane onto the detector with the same aperture ratio as without the coronagraphic system. The optics is made of fluoride glass, to be transparent in the thermal bands. Masks of different size are aligned on a sliding thin plate in order to move quickly from one to another by translation. The masks and the Lyot stop are manufactured by a microphotolithography process. The Lyot stop is only used when the mask size is large compared with the FWHM of the point-spread function FWHM. The masks are movable in X and Y directions by a remote-control motorization. The centring accuracy is about one tenth of the pixel size on the sky. The size of the masks ranges from 95 to 460 microns, which corresponds respectively to 0.27 and 1.3 arcsec on the sky for F/20 aperture. Every element, except the lens L1, is fixed on a movable bench in order for commutation between the normal mode and the coronagraphic one to be fast and easy.

The first test was made in January 1991 at the 3.6-m ESO telescope at La Silla, Chile, during the adaptive optics runs. The vertical motion of the masks was not yet motorized and the centring via the On-Off mirror tilt was accurate to only half a pixel. Therefore, no reliable observations were obtained, but the concept was validated. The second test took place during the April-May 1991 COME-ON run. Although a parasitic reflection in the cryostat strongly limited the elementary integration time for faint stars, we succeeded in obtaining very good coronagraphic images of bright point-like stars (see Fig. 2), in particular Sirius. We did not find the suspected third companion, because the detector field was too small (3 arcsec) and we could only observe during a short period at the beginning of the night.

The main result is the confirmation of the contrast gain. In the case of diffraction-limited coronagraphic imaging, a mask which occults the Airy pattern up to the first dark ring stops 84 % of the light. If it stops the light up to the second dark ring, 91 % is obscured. It means that the rejection rate (total light to not occulted light ratio) of such a mask is 6.3 in the first case and 11.1 in the second one. With Sirius observed in the



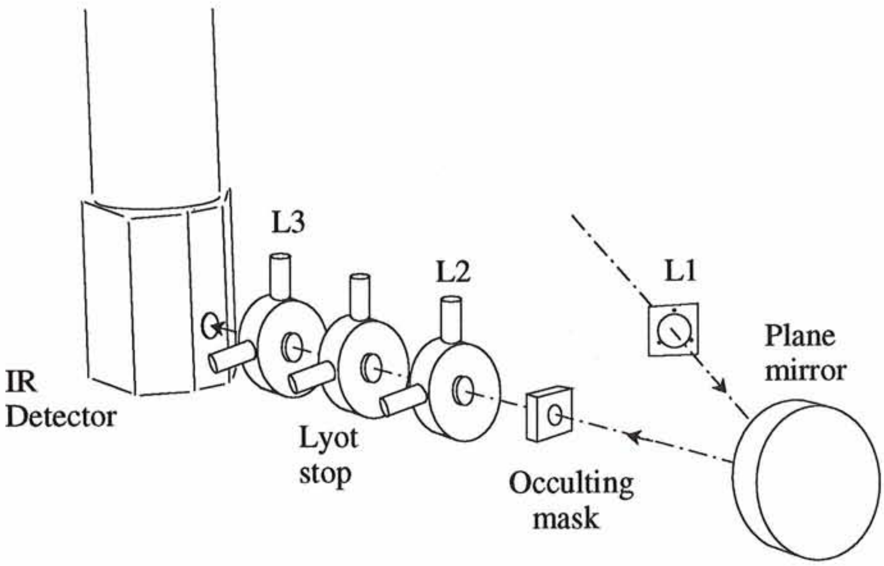


Figure 1: *The coronagraph installed at the focus of the VLT adaptive optics system COME-ON.*

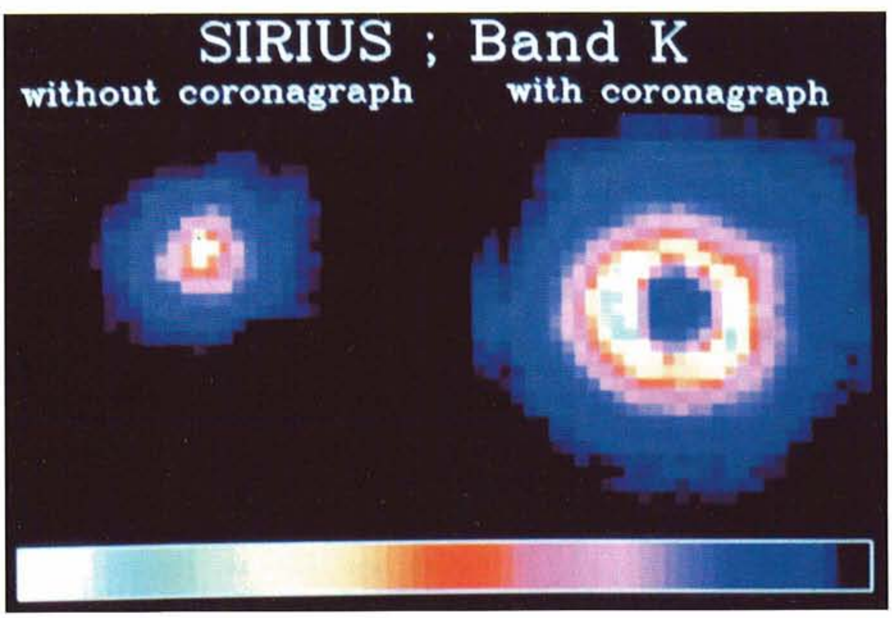


Figure 2: *Sirius images, without and with coronagraph in K band. The elementary integration time has been divided by 12 (192 ms vs 16 ms) between the two images. The pixel size is 0.101 arcsec.*

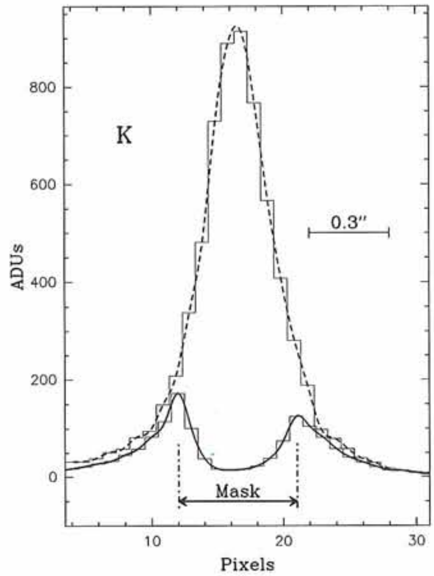


Figure 3: *Profile of a point-like star observed with and without coronagraph. The overlay between the two curves outside the mask is remarkable (the two profiles have been slightly displaced in order to increase the visibility of the figure).*

K band, we chose 16 ms as the elementary integration time to avoid detector saturation. With the coronagraph, we could reach 192 ms, i.e. 12 times longer. For another star, the gain in elementary integration time was 8.33. This demonstrates the ability of the coronagraph to increase the elementary integration time so that the signal-to-noise ratio goes as t rather than $\sqrt{t}$, as one is limited by detector read-out noise. Another point is the radial dependence of the intensity. Figure 3 shows that the radial profile of the point-spread function is not modified by the coronagraph beyond a distance equal to the sum of the mask radius and of the point-spread function half width at half maximum. If the star is not perfectly centred, the result is not changed but the maximum intensity is increased and, consequently, the elementary integration time is decreased.

These two runs allowed us to demonstrate the gain of coupling a coronagraph to an adaptive optics system. The expected and demonstrated gain is not only in resolution, but also in signal-to-noise ratio. An updated version of the coronagraph is undertaken to fit COME-ON+, the new adaptive optics system for the 3.6-metre telescope, to be put in operation at the end of 1993.

Acknowledgements

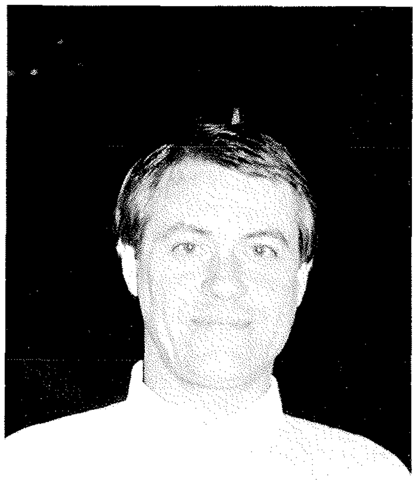
I thank C. Marlot and P. Gigan, who kindly helped to build the coronagraph, and also V. Serpette and F. Gex from the

Observatoire de Paris (DASGAL), for providing me with the masks and the Lyot stop. F. Rigaut ran COME-ON during the observations and N. Hubin helped to install the coronagraph on the COME-ON adaptive optics system.

References

Malbet F., to be submitted to A&A.

Jean-Luc Nieto (1950–1992)



Jean-Luc Nieto was born in Algiers in 1950, and came to France in 1962. He studied in Paris, obtained a Master's degree in mathematics, and in 1974, he received an engineering degree from the Ecole Centrale as well as a graduate degree (DEA) in astrophysics. He then worked on a doctoral thesis (doctorat de troisième cycle) under Jean-Claude Pecker.

In January 1977, Jean-Luc went to the University of Texas in Austin for a post-doctoral fellowship. He began to study galaxies with Gérard de Vaucouleurs. Two years later, he was hired at the Observatoire du Pic-du-Midi at Bagnères-de-Bigorre. In 1983, he moved to Toulouse, within the same observatory, where he obtained his PhD in 1984.

During the 15 years of his scientific career, Jean-Luc Nieto earned an international reputation in the area of high-resolution imaging with the purpose of understanding the nature and origin of extragalactic jets, and later of elliptical galaxies. Working tirelessly, he collaborated in many research projects – national as well as international – where his enthusiasm made him a driving force of many of them. All the big telescope domes – of ESO, CFHT – rang with his discoveries at one time or another. He played a leading role in the preparation and development of an ESO key programme to establish a physical classification of elliptical galaxies, bringing on active collaboration with the Observatories of Padua and Heidelberg.

His reputation earned many responsibilities: president of an IAU working group (1982–88), member of the French committee for telescope-time allocation (1982–83), lecturer at the National Aeronautics School since 1984, associate professor at the University of Padua in 1985, team supervisor at Observatoire Midi-Pyrénées since 1986. The French scientific community recognized the value of his work with the CNRS bronze medal in 1986.

Jean-Luc Nieto died on January 5, 1992. We will all remember his energy, his impulsiveness and his creativity, the passion with which he defended his scientific projects. His temerity and refusal to set limits did not always let us follow him, but we respected him for his bold and unique approach. After spending a year as visiting astronomer in Hawaii at the Canada-France-Hawaii telescope, he was preparing to work on exceptional images of central regions of elliptical galaxies obtained at CFHT and NTT. Mountaineering, one of his passions, took him away from us.

E. DAVOUST
(on behalf of French astronomers)

ESO at EXPO '92

A grand fiesta, lasting for 176 days and with more than 18 million participants, this is what the ancient Andalusian city of Seville is looking forward to as the final preparations for EXPO '92, the Universal Exhibition, now move into high gear.

On an area covering 215 hectares on the island of La Catuja, more than 100 pavilions have risen during the last 18 months. Most of them are national pavilions or represent geographical regions. Others are specifically devoted to the main theme of this Universal Exhibition: "The Age of Discovery".

Among the string of specialized pavilions is the "Present and the Future Pavilion", a 10,000 square metre building which will house exhibitions on robotics, energy, communications, artificial intelligence, etc. It will also be the home of an exhibition which has been put together by CERN, ESA, EMBL and ESO as well as by several Spanish research institutes. There will also be a planetarium, models of various ESA spacecraft, laboratory equipment from CERN including a big custom-built spark chamber, through which courageous visitors can walk and "see" the cosmic particles which pass through them.

ESO will show a huge, interactive model of its 16-m Very Large Telescope, together with short, specially-produced videos on different types of front-line astronomical programmes which will be undertaken with the VLT. Inside this pavilion there will also be many large colour photos from ESO on display, as well as an 11-m long photographic ESO-produced transparency of the Milky Way. And last, but not least, the outside entrance of the pavilion will be covered with a 400 square metre ESO colour photo (the largest astronomical enlargement ever made?) of a spiral galaxy. It is so large that it should be easy to see it from the city of Seville, across the river of Guadalquivir.

A universal exhibition like EXPO '92 has been described as one of the most comprehensive and ambitious cultural events of our time. It is a forum for demonstrating all facets of human endeavour. It brings together presentations of the latest advances in the arts, technology and sciences. As such it is a most fitting place to present the 16-m VLT project to the public at large.

. . . and in other places

On a smaller scale, ESO's own exhibition continues its travels on two continents. It closed in Santiago de Chile on January 23, 1992, when certain parts of it moved north to form a stand at the annual Penuelas Fair in La Serena, which opened on January 30 and closed on February 9.

On the day of the inauguration, the first visitor to the stand was the Minister of Agriculture, Mr. Figueroa, to be followed, a few days later, by the Minister of Mining and Energy, Mr. Hamilton. Further the Governor and deputies and senators for the IV Region of Chile, the

Intendente for the IV Region, Mr. Fuentealba, as well as the mayors of La Serena and Coquimbo paid visits to our stand.

At this highly successful fair, ESO astronomer Patrice Bouchet and night assistants Eduardo Matamoros and Rolando Vega together with Jorge Peralta took turns at the stand . . .

Finally, at the closing ceremony, ESO was awarded a special distinction for its presentation, also a sign of the interest by the public in the activities of our organization.

Not counting the Penuelas fair, which as usual attracted some 80,000 visitors, the ESO exhibition has until now been seen by more than 250,000 people during its South America tour.

In Europe, the exhibition at the Planetarium in Berlin has been a major success, and to satisfy the public demand, the exhibition has been extended beyond the originally foreseen closing date of March 1, 1992.

Among the upcoming events are complete exhibitions and fair stands in Milan (Italy), Jena (Germany), as well as Antofagasta and Santiago de Chile.

C. MADSEN, ESO

The 3 × 4.5 metre giant model of the Very Large Telescope on Paranal arrives at the ESO Headquarters on February 6, 1992. Here it was outfitted with computer and video equipment before continuing to Seville in early March. It was built in record time by the Swedish firm Linovation and also shows the new enclosures, as decided late last year. The model incorporates a projection system by means of which VLT video films can be shown on a wall behind the model. The videos are stored on a computer-controlled videodisk and activated by the visitors.

NEWS FROM THE VLT ADAPTIVE OPTICS PROTOTYPE PROJECT:

A New Photon Counting Wavefront Sensor Channel for COME ON PLUS

N. HUBIN and E. GENDRON, ESO

As part of the upgrading programme of the VLT adaptive optics prototype system, called COME ON PLUS (see *The Messenger* Nos. **60** and **65**), the wavefront sensor (WFS) channel is currently redesigned. In the new configuration two visible WFS channels can be selected from the observing room via a remote control: one channel for star magnitudes in the visible up to 11 equipped with an intensified Reticon array and a second channel for star magnitudes from 9 up to the limiting magnitude of 15 equipped with an electron bombarded CCD (EBCCD). This configuration allows to overcome the limited signal dynamics of the EBCCD low flux detector.

The EBCCD tube, developed at Laboratoires d'Electronique Philips (LEP) is derived from a Philips first-generation image-intensifier tube (see Figure). It is a single-stage triode tube including a thinned back side directly bombarded CCD (604×288 pixels) instead of the phosphor screen. A cooled S25 photocathode reduces the dark current down to 35 e/frame/s. The intensification factor can be selected from 100 to 1400. It is particular of this tube that the gain is very accurately defined compared to the enormous gain dispersion of other intensification schemes

Figure 1: *Tube assembly of the electron-bombarded CCD built by LEP.*

due to the intermediate phosphor stage: this property makes the EBCCD tube quasi perfectly quantum noise limited, without any temporal constraints in the number of photons per time unit.

The limited photon noise is of great importance for the optimization of the modal control scheme currently being implemented in COME ON PLUS. In particular, it will allow to decorrelate the number of modes corrected by the deformable mirror from the number of subapertures needed for the wavefront measurement. This number of subapertures is kept fixed, whatever the observing conditions are, even for very low signal-to-noise ratio. A programmable integration time (2.5 to 40 ms) is provided in order to cope with low flux levels.

The first performance tests under real observing conditions with the EBCCD integrated in the upgraded COME ON PLUS system are planned for September/October 1992.

A New Cross Disperser for CASPEC

L. PASQUINI, G. RUPPRECHT, A. GILLIOTTE and J.-L. LIZON, ESO

1. Introduction

In an earlier report about the upgrading of CASPEC, the Cassegrain Echelle Spectrograph attached at the 3.6-m telescope, the future installation of a new RED cross disperser was announced (Pasquini and Gilliotte, 1991).

The main reason for the need of a RED cross disperser was that the overall CASPEC capabilities at wavelengths longer than ~600 nm were rather poor, despite the good efficiency of the Tektronix chip at these wavelengths (CCD # 16). Because the principal cause of poor efficiency was the low response of the standard (hereafter BLUE) cross disperser, a new grating was acquired having the peak efficiency in the red part of the spectrum.

The cross disperser for CASPEC is formed by a mosaic of two gratings; they were assembled and aligned in Garching and the mosaic arrived at La Silla at the end of 1991. The characteristics of the cross disperser are given in Table 1 and its efficiency curve is shown in Figure 1.

Due to problems occurred during the Garching–La Silla transfer, it was necessary to re-install the cross disperser in its support at La Silla and at the beginning of January the mosaic was successfully mounted and tested on CASPEC with the Short Camera.

2. Performance

The optical quality of the grating is very good, and the spectra are free of ghosts and internal reflections.

Table 1: *Characteristics of the red cross disperser grating*

Groove density	158/mm
Blaze wavelength	800 nm
Blaze angle	3°38′

The instrument configuration is rather stable. In particular the counterweight system, which is similar to that used with the BLUE cross disperser, was found to work properly.

The spectral range covered in one frame is large, about 280 nm with the Tektronix CCD actually mounted on CASPEC. This of course implies that the order separation is rather small (about a factor 2 smaller than with the BLUE cross disperser). The order separation as a function of the order number is given in Figure 2. For wavelengths below 550 nm this separation is less than about 6 arcseconds (the spatial scale with the short camera is of 24 arcsec/mm in the direction perpendicular to the dispersion).

This implies that below ~550 nm the RED cross disperser can be hardly used, and that only with a very short slit can order confusion be avoided. As a consequence, *for observing programmes which require BLUE and RED spectra in the same night the RED cross disperser is not suitable.* The small interorder space must be taken into account also for all applications requiring a proper sky subtraction.

As expected, the CASPEC efficiency in the red is greatly enhanced: the efficiency of the Short Camera + RED Cross disperser + CCD 16 has been measured through observations of standard stars and is given in Figure 3 (filled triangles).

During the same test run the efficiency of the Short Camera + BLUE cross disperser + CCD 16 was also measured,

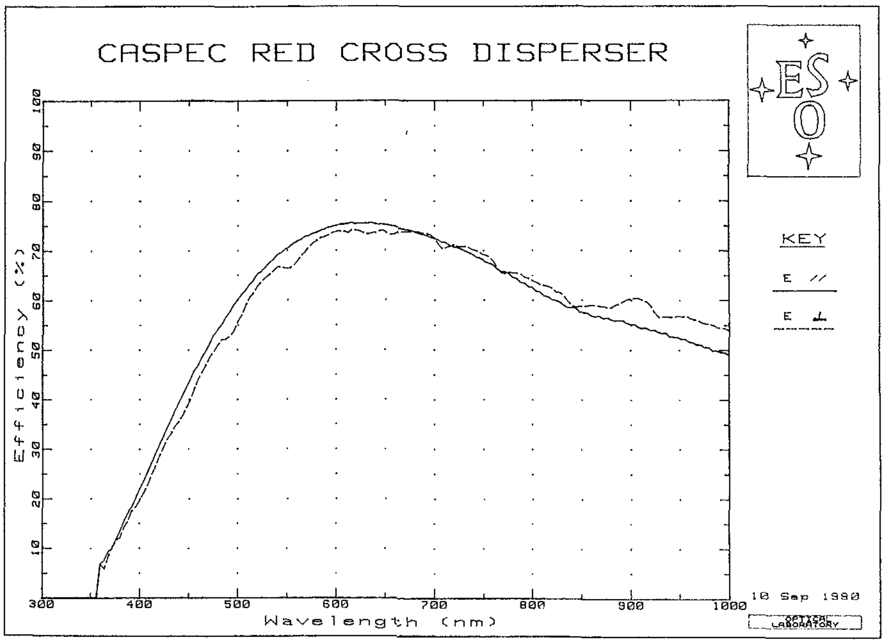


Figure 1: *Efficiency curves for the RED cross disperser for polarization parallel and perpendicular to the grooves.*

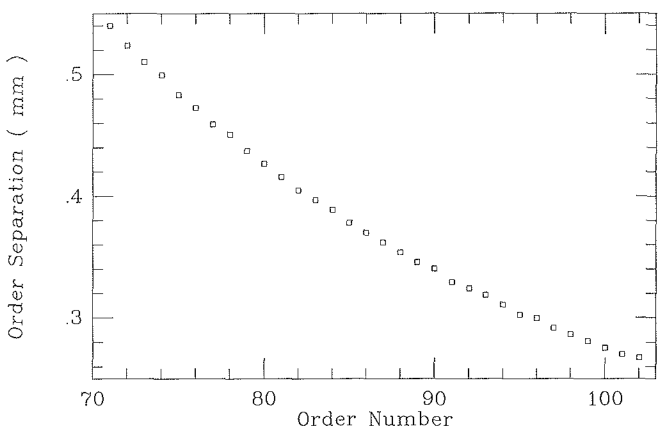


Figure 2: *Interorder separation (in mm) vs. order number for CASPEC + short camera + 31.6 lines/mm echelle and RED cross disperser.*

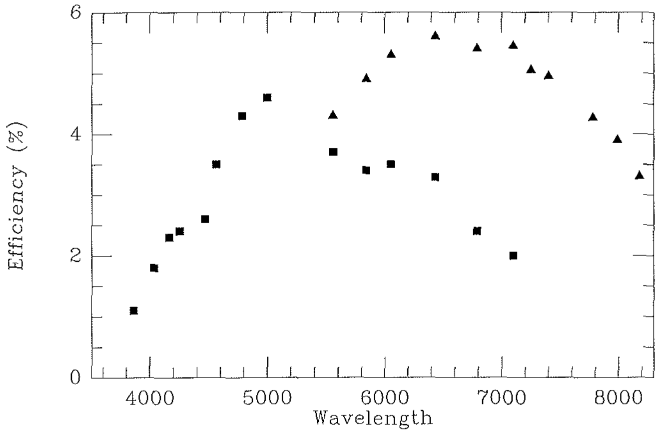


Figure 3: *Overall efficiency curve including 3.6-m telescope + CASPEC (short camera and 31.6 lines/mm echelle) + CCD 16; filled triangles: RED cross disperser; filled squares: BLUE cross disperser.*

and the results are also given in Figure 3 (filled squares). The dramatic improvement due to the use of the RED cross disperser is easily recognizable.

We note that the efficiency curve of CASPEC and the BLUE cross disperser is higher than that given in Pasquini and Gilliotte (1991); this is due to two factors:

(1) The CCD was UV flooded.

(2) The procedure previously used tended to underestimate the efficiency at blue wavelengths.

3. Practical Hints

A few comments are necessary regarding the practical use of this new configuration:

(1) There is no order overlap at wavelengths longer than ~815 nm.

(2) A colour filter (CASPEC colour filter 2 or 1, according to the chosen spectral range) must be used in order to avoid second-order contamination, *both* in the calibration spectra *and* in the scientific exposures.

(3) If requested, the RED cross disperser will be mounted and it can be considered officially offered, but potential users should note that the *change of cross disperser in the course of the night is not allowed.*

References

Pasquini, L., Gilliotte, A. 1991: *The Messenger*, **65**, 50.

News About Imaging Filters

A. GILLIOTTE, J. MELNICK and J. MENDEZ, ESO-La Silla

ESO is actually offering different sets of image quality filters which can be used on all imaging instruments at La Silla. Filter sets exist in different copies, of which only one is reserved at one instrument. A basic filter set includes the Bessel (U, B, V, R, I), Gunn (g, r, i, z) and four interferential (Hα, Hαr, SII, OIII) filters. Other filters are also available with a lower number of copies; they can be used only on one imaging instrument. Filters have now an external diameter of 60 mm and a maximum thickness of 10 mm. They are mounted on a metallic ring for easy manipulation. ESO offers around 200 image quality filters.

Since November 1991, a new image quality filter list is available at La Silla. Access of data can be obtained directly with the help of a new programme developed here under MIDAS.

Filter parameters and curves can be obtained with simple softkey menus. The programme is accessible with Sun stations under MIDAS with the command SET/CONTEXT FILTERS. Filter list, search, plot, overplot are also possible with laser hardcopy facilities.

All available image quality filters have been measured according to two sets of parameters. The first concerns the spectral performances as central and peak wavelengths, the full width at half maximum bandwidths, the peak transmission and the eventual red-leak. Quality performance is also indicated in terms of eventual image deformations as elongation, blurr effect and the eventual presence of ghost images. Ghost images can be disturbing even with a relative intensity difference of 10^4 with the main image.

All filters will soon be checked again, especially concerning the red-leak blocking performances with the help of a new powerful spectrophotometer recently purchased.

The image quality filter database will be constantly updated with the new filters or with eventual filter removing after damages.

MIDAS Memo

ESO Image Processing Group

Most information concerning MIDAS is now published in the *ESO-MIDAS Courier* which was introduced in 1991 as a newsletter for the MIDAS users community. The MIDAS Memo is therefore no longer required and will be discontinued as a regular column. The Image Processing Group will still announce new major developments in the *Messenger* but it will happen only when called for e.g. at major new releases of MIDAS.

1. Application Developments

During a three-month visit at ESO, Luca Fini has made a number of significant improvements of the AGL plotting library. These include both general optimization and new features such as more fonts and support of different coordinate systems.

The first test version of an X11 Graphics User Interface (GUI) for MIDAS was made at La Silla to make it easier to use the spectral package. To gain experience in how to customize such GUI's, a test implementation was also made for the Echelle package being one of the more complex applications. It is expected that these prototypes, tests for remote observing and requirements for the VLT will make it possible to define a consistent GUI for ESO.

2. MIDAS Bulletin Board

A bulletin board for MIDAS issues has been created using the USEnet News system. This prototype was installed as a local News group in ESO with the name 'eso.midas'. It can be accessed directly at ESO while external sites would have to use the 'esobb' account on 'bbhost.hq.eso.org' to read it. Sites with an implementation of USEnet News may later be able to get the bulletin board transferred automatically. MIDAS users are welcome to post messages by e-mailing them to the moderator Rein Warmels at 'rwarmels@eso.org'.

3. MIDAS Hot-Line Service

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

- EARN: MIDAS@DGAESO51.bitnet
- SPAN: ESO::MIDAS
- Eunet: midas@eso.uucp
- Internet: midas@eso.org
- FAX: +49-89-3202362, attn.: MIDAS HOT-LINE
- Tlx.: 52828222 eso d, attn.: MIDAS HOT-LINE
- Tel.: +49-89-32006-456

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

More information about MIDAS can be found in the *ESO-MIDAS Courier* which is the biannual newsletter on MIDAS related matters issued by the Image Processing Group and edited by Rein Warmels.

Things that Pass in the Sky

This issue of the Messenger *contains three contributions about things seen in the sky by astronomers – they represent three different experiences of different origin and impact.*

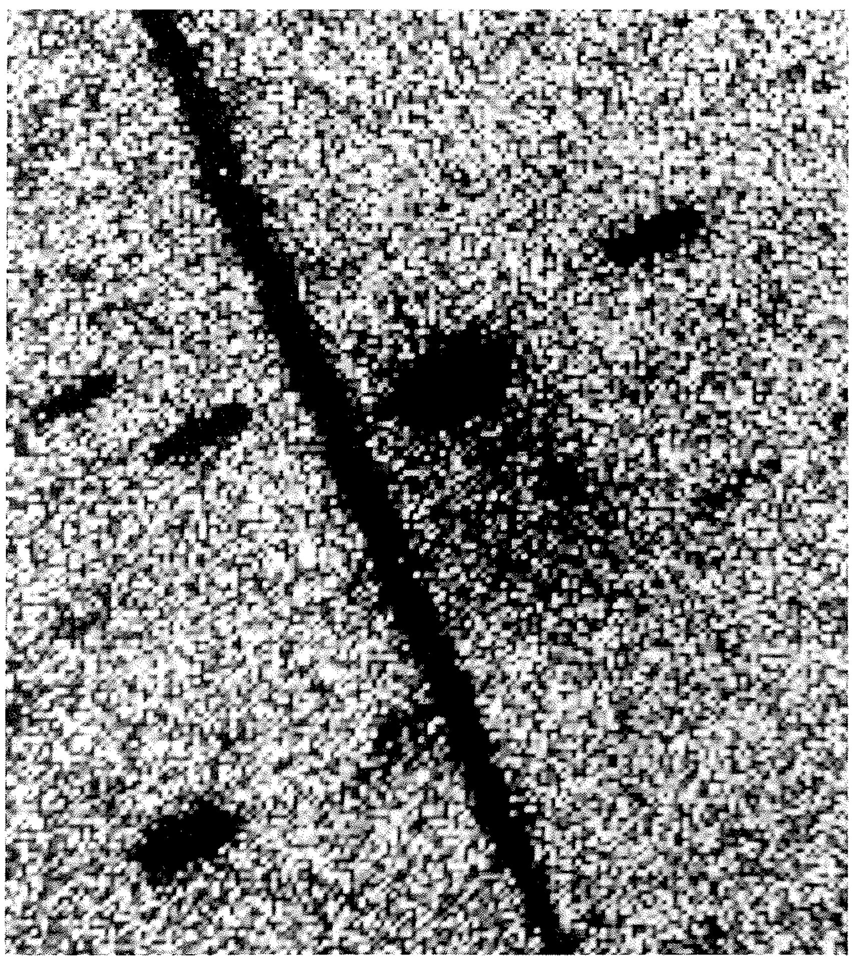
During the past decades, many observers and in particular those who work at wide-field instruments have become aware of an increasing "pollution" of the skies by artificial satellites. More and more objects fly around the Earth in high and low orbits and it is getting more and more difficult to obtain "clean" astronomical images. Even CCD observers begin to feel the problem; I myself have had at least one satellite trail in a CCD frame during each of my recent missions to La Silla, cf. the picture below.

The following article is based on a project by students at the European School in Munich (the first author is the daughter of one of the astronomers at the ESO Headquarters) and quantifies the increasing threat to observational astronomy. It should serve as a warning light for all interested in our science.

But there are other things in the sky. The fall of a rocket stage was recently seen by thousands of people along the Chilean coast and was photographed by an astronomer at ESO – the story is told in this issue. This is the type of event that gives rise to myths; unless a scientifically sound explanation is quickly found, there is little doubt that another UFO story will soon spread all over the world through the news-hungry media.

And then there is the third... What to believe? Two reliable observers see a not-so-fast-moving object which does not look natural, and might even be a small comet passing very close to the Earth. There is no doubt that the object was real, the photos show that. But what was it really?

An old proverb says (at least in Scandinavia): "There is more between the sky and the Earth than what meets the eye". Some astronomers might say: too much! The editor



Satellite trail crossing the CCD image of P/Halley on March 14, 1991 between UT 3^h48^m and 4^h33^m, i.e. just before local midnight at La Silla. The Danish 1.54-m telescope followed the motion of the comet, so the images of the stars are trailed.

Astronomical Light Pollution by Artificial Earth Satellites

EMMA FOSBURY[1], ALISON TURTLE[1] and MICHAEL BLACK[2]
[1]European School Munich, Germany; [2]University of St. Andrews, Scotland

Since the launch of Sputnik 1 in 1957, the space programme has expanded to become an integral part of our lives in a multitude of ways. Many nations contribute, very many benefit and a growing number have the technological ability to launch spacecraft into Earth orbit. While we may appreciate many of the results, e.g., vastly improved communications, satellite TV, better weather forecasts, etc., and we certainly value the contribution to astronomy and science in general, there are a number of side-effects which cause considerable concern. The physical dangers to spacecraft inherent in the increasingly crowded near-earth environment have caused both NASA and ESA to examine the risks and propose tighter management of their missions to avoid further unnecessary litter (ESA set up a "Space Debris Working Group", chaired by Flury, 1988). There are particular dangers to manned missions in low-earth-orbit (LEO) and large structures like the space station "Freedom" risk a high probability of collision and damage. The Hubble Space Telescope risks a 50 % probability of collision with a particle smaller than 5 mm in its proposed 17-year lifetime (Shara and Johnston, 1986). The Geostationary orbit is, understandably, crowded and measures are now usually taken to remove expiring satellites and place them in safe "parking orbits", freeing space for replacements.

Ethical issues are raised by catastrophically polluting military programmes (e.g. Star Wars) which propose the physical destruction of orbiting objects, a process which could trigger an exponential rise in the amount of space debris as fragments collide with other fragments or working satellites. Also, proposals to erect "Space Art" (Malina, 1991) are particularly worrying for astronomers since these, by their nature, aim to reflect the maximum quantity of sunlight towards their earth-bound audience (Murdin, 1988, Malina, 1991).

As the subject for an International Science Symposium project (Junior Science and Humanities Symposium), we have investigated one aspect of the pollution caused by earth satellites – both currently working and "dead" objects in orbit. That is the effect of reflected sunlight from artifical satellites on astronomical observations (see Fig. 1).

For a summer project in 1988 at the Royal Observatory Edinburgh, one of us (MB) counted the trails on approximately 1,000 IIIaJ and IIIaF UK Schmidt* plates (6° by 6° FOV) obtained during several sky survey programmes from 1974 over a fourteen-year period. The trails were categorized into groups of "bright", "medium" and "faint" (close to the plate limit) objects with a further category of "flashing" which covered the whole brightness range. Using the

* The 48-inch Schmidt Telescope at Siding Spring in New South Wales in Australia is now operated by the Anglo Australian Observatory.

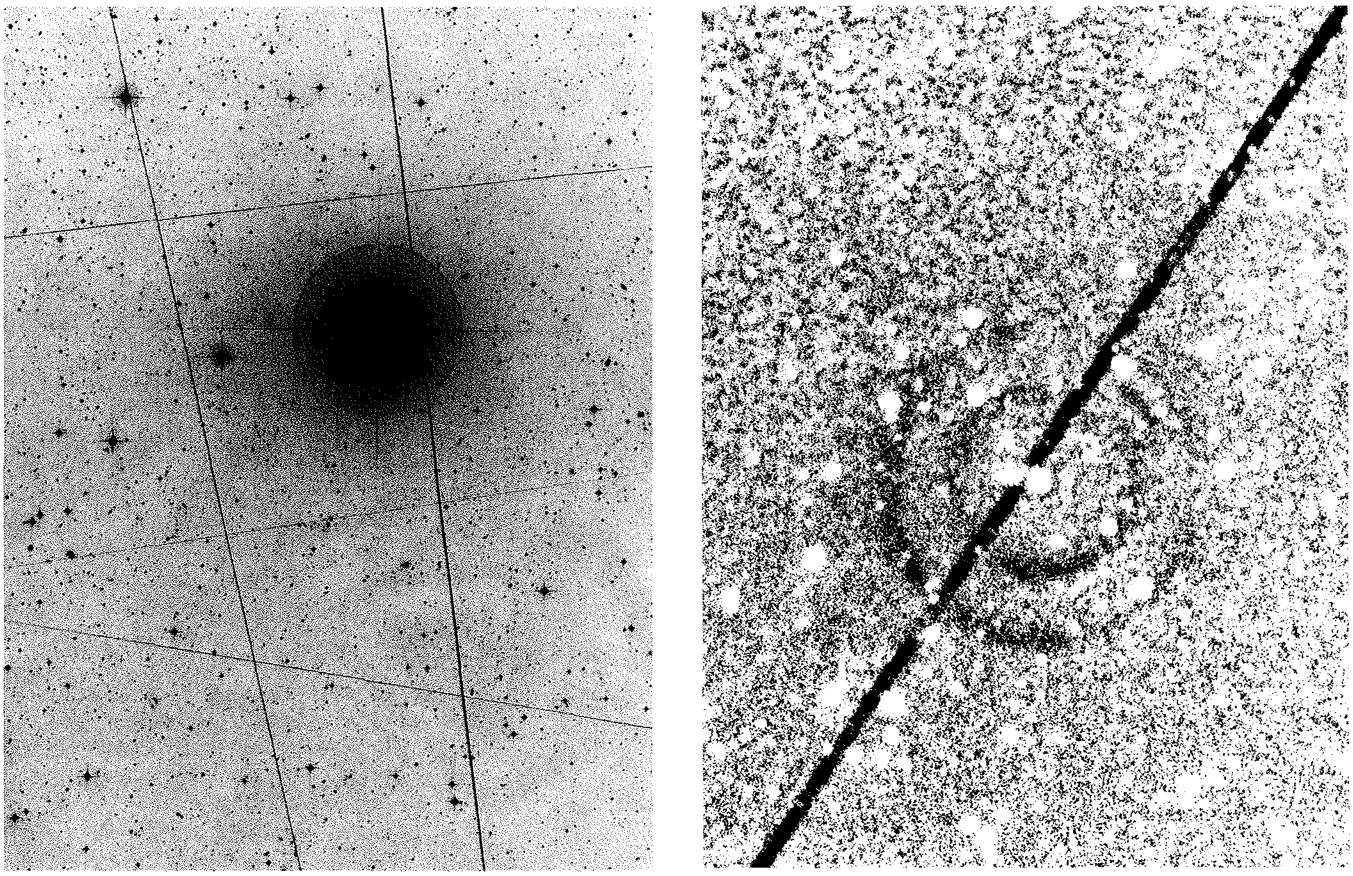
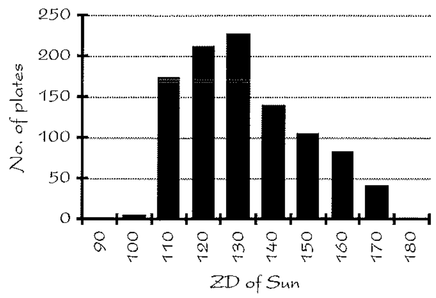


Figure 1: *(a) Five trails of differing brightness on UK Schmidt plate No. J14710 (Courtesy: David Malin, AAO).*
(b) The light echoes around the remnant of Supernova 1987A. A case where a trail has ruined an exposure (Courtesy: David Malin, AAO).



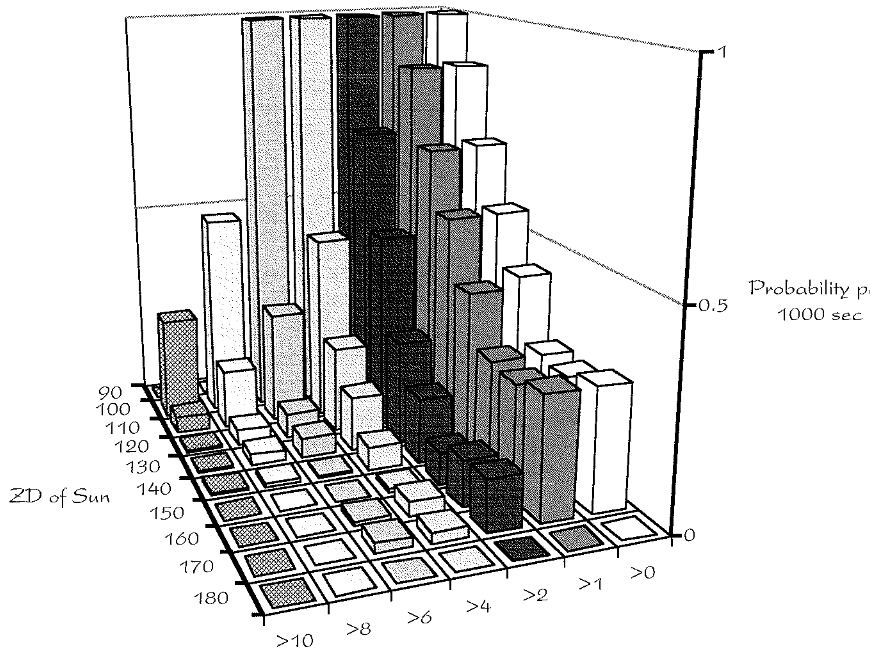


Figure 2: *The 2-D plot is the frequency distribution of the quantity of interest for all the plates. The 3-D plot shows the frequency distributions for alle the plates with > n trails per 1000-second exposure normalized by the unselected distribution – this gives the probability of finding at least this number of trails on a plate. The plot shows the distribution as a function of the zenith distance of the Sun. As expected, most trails are found near twilight – this is the time when even the low orbit satellites are still outside the shadow of the Earth.*

date and time of the plate, the exposure time and the plate centre, we constructed a catalogue containing the solar zenith distance, the angular separation of the sun and the plate centre and various other angles of use in describing the geometry of the Sun–Earth–Observatory–satellite system. The resulting table was defined as a "database" in a Macintosh "Excel" spreadsheet, simplifying the subsequent task of extracting multiply selected subsets.

Our primary method of visualizing the data was to construct normalized frequency distributions giving the probability of counting a given number of trails on a 1000-sec-exposure plate as a function of various angles. Figure 2 is an example which demonstrates the (expected) tendency to see most of the trails on plates taken during twilight ($ZD_{sun} \sim 100°$). This shows immediately the seriousness of the problem: essentially every plate taken close to twilight contains several trails.

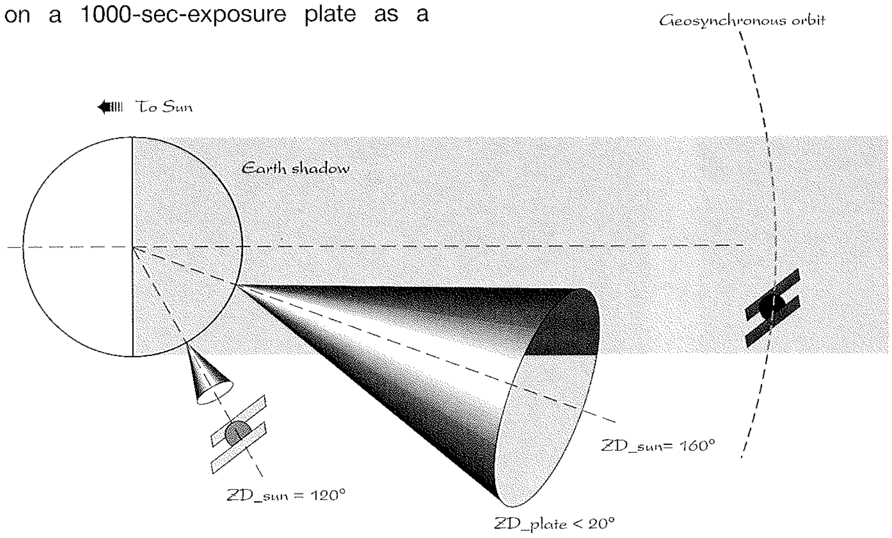
The relevant geometry can be understood from Figure 3 which shows how a satellite will enter the Earth's shadow at a Sun–Earth–satellite angle (θ) which depends on its orbital altitude. This suggests a method of making a statistical separation of the low Earth orbit (LEO) and the high and Geosynchronous satellites. It also allows us to determine the background contamination by (self-luminous) meteors which will be the only objects seen when looking along the Earth-shadow. Figure 4 shows the result of selecting only those plates with $\theta<120°$ or $130°$ – near twilight – and those with $\theta>150°$ – where only the higher objects will be seen outside the shadow. The latter suggests that the detected meteor flux is very low and does not significantly contaminate the measures of satellites. This is, presumably, because meteors – while they can have a high apparent brightness – generally move too fast across the field of view of the telescope to generate a significant exposure.

Given the fourteen-year time-base covered by the measured plates, we searched for evidence of a secular change in the probability of having plates affected by trails. This was done by computing the linear regression against calendar time of the number of trails per plate per 1000-sec exposure for (a) all the plates, (b) plates with $\theta<120°$ (LEO objects) and (c) those with $\theta>150°$ (high and Geostationary objects). In order to determine the error on the slope of the resulting regression lines, we took 30 repeated "bootstrap" samples from each of the selections and took the width of the resulting slope distribution functions to represent the uncertainty. The resulting slopes and their errors are:

(a) all plates, 0.190±0.014 trails/1000-sec exposure plate/year

(b) $\theta<120°$, 0.299±0.046

(c) $\theta>150°$, 0.115±0.013



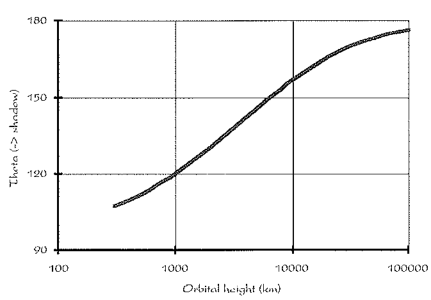


Figure 3: *(a) This drawing explains our ability to separate the populations of low- and high-orbiting objects using the angle between the Sun and the plate centre, θ (see text), as a discriminant. When looking down the Earth-shadow, only self-luminous objects (meteors) can be seen: we discover that these are very rare on the Schmidt plates.*
(b) The plot shows the angular separation of the Sun and the plate (at $ZD_{plate} = 0$) at which the satellite enters the Earth's shadow.

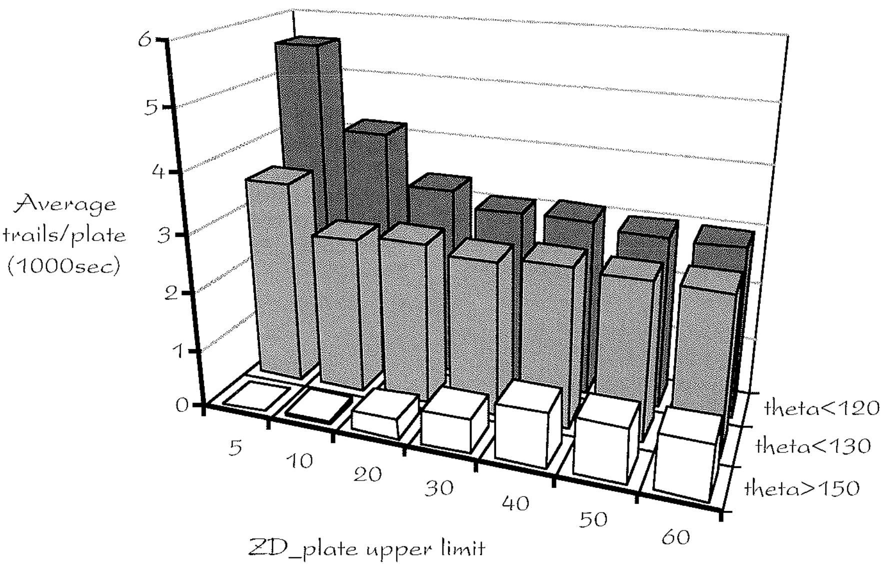


Figure 4: *This shows our use of geometry (the angular separation of the Sun and the plate) to separate the populations of low and high (probably mostly Geosynchronous) satellites. By looking at the average number of trails per plate with $\theta > 150°$ or $\theta < 120°$ and 130°, we see mostly high or low objects respectively. When the zenith distance is limited to lower values, the discrimination between these populations becomes sharper.*

This shows that the LEO objects are increasing the fastest while the high altitude objects show a slower, but still significant, rise.

Finally, we attempted to estimate the sizes of the objects which produced the trails of different strengths. This involved knowing the distance between the satellite and the observatory, the albedo and the "phase-angle" of the satellite and the orbital altitude – which determines the angular speed with which the satellite crosses the plate and hence the "effective exposure time." Figure 5 shows the choice of this effective time to be that taken for the image to travel a distance equal to a typical seeing disk (we assumed 1 arcsec). The two graphs show the apparent magnitude of a trail produced by objects of "radius" (we assumed a diffusing sphere with an albedo of 0.5) 20 cm and 4 m. These are the smallest objects we could expect to detect at LEO and Geosynchronous heights respectively. Note that the strength of a trail on a plate does not depend on the exposure time although, of course, the image of a star with which it is compared does.

In conclusion, we remark that, while in the early days of the ESO/SERC Southern Sky Survey project, "A"-grade plates could not contain a satellite trail, it is now virtually impossible to maintain this criterion. There is even one case (at least) of a trail being recorded on an exposure taken with the Wide Field Camera on the Hubble Space Telescope. This has a field of view some two million times smaller than that of a Schmidt plate! Astronomers should be aware of the necessity of the various space agencies and vehicle launching organizations to take a responsible

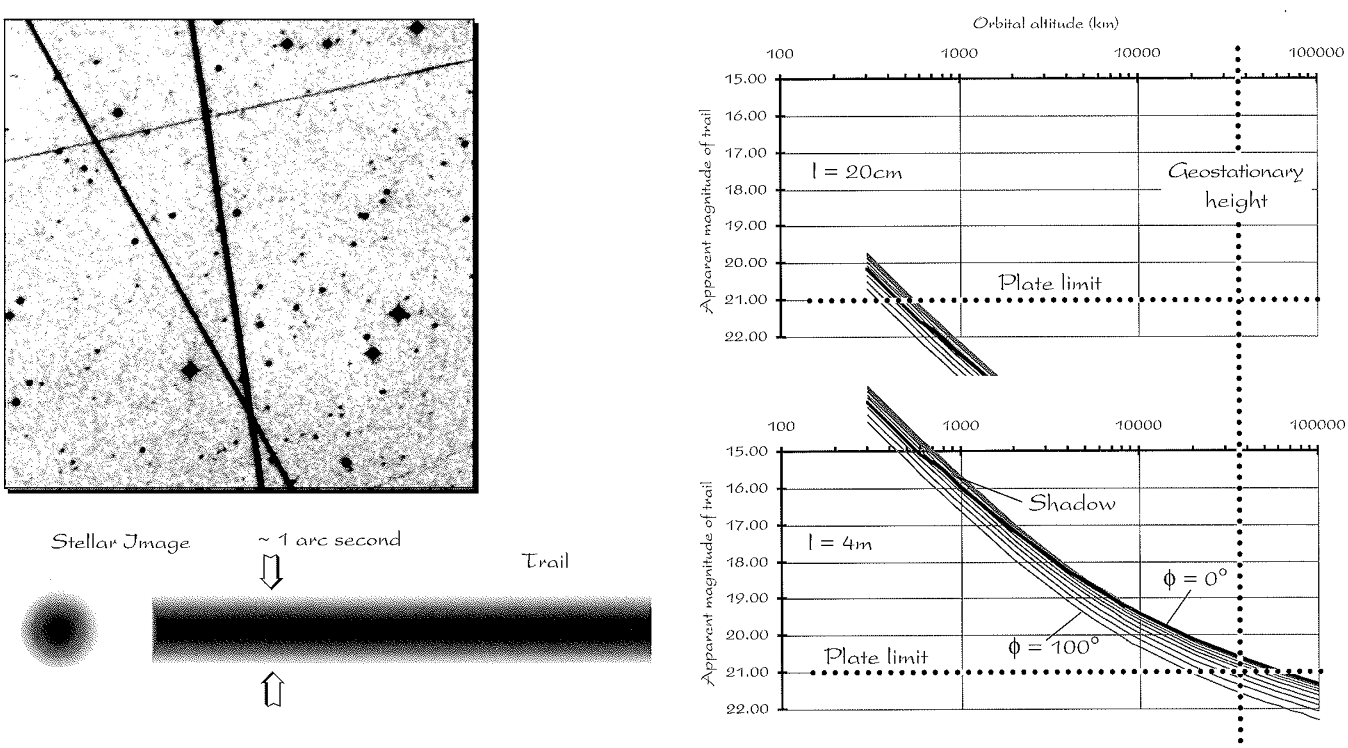


Figure 5: *(a) The appearance of a trail on a plate. Most of the satellites will appear so small to a ground-based telescope that they will be unresolved and so look like stars drawn out into a trail. The typical angular size of a stellar image on a plate is (at best) about an arcsecond. In our calculation of the apparent brightness of a trail, we compare the exposure of a satellite during the time it takes to cross its own diameter with that of a star (the exposure time of the plate). The strength of a trail as registered on a plate is therefore independent of the exposure time of the plate, unlike the stars with which the trail is compared.*
(b) Our calculation of the expected brightness of satellites as a function of altitude, phase angle (φ) and "size". We have adopted an albedo of 0.5 and show results for a (diffusing spherical) satellite of radius 20 cm and 4 m, limiting sizes to be seen at LEO and Geosynchronous altitude respectively.

attitude towards minimizing this source of pollution.

Acknowledgements

We should like to thank Dr. Bob Fosbury and Hans-Martin Adorf (ST-ECF), Sue Tritton, Mike Read and Myra Cranston (ROE), Dr. Linda Walsh (ESA), Dr. David Malin and Dr. Ann Savage (AAO), Prof. H. Haubold (UN) and Mr. Nigel Evans (ESM) for their help and encouragement.

References

Fleury, W. (ed.), 1988. *The Report of the ESA Space Debris Working Group*, ESA SP-1109.

Malina, R.F., 1991. "In defence of Space Art: the role of the Artist in Space Exploration", in *Light Pollution, Radio Interference and Space Debris*, David, L. Crawford (ed).

Murdin, P., 1991. "The threat to Astronomy by Space Art", in *Light Pollution, Radio Interference and Space Debris*, David, L. Crawford (ed).

Shara, M.M. and Johnston, M.D., 1986. "Artificial Earth satellites crossing the fields of view of and colliding with orbiting Space Telescopes", *Pub. Astr. Soc. Pacific*, **98**, 814–820.

Unidentified Object Over Chile

O. HAINAUT, ESO-La Silla

During the night between January 23 and 24, 1992, a very uncommon object, in public terminology denoted as "Unidentified Flying Object (UFO)" passed over Chile. It was seen by thousands of people, from Villa O'Higgins (2100 km south of Santiago) to Copiapo (700 km north of Santiago and 200 km from La Silla).

Journalists of *El Mercurio* (the major Chilean newspaper) described the phenomenon as "a luminous cloud moving northward, from which suddenly grew a mushroom, like the one of an atomic explosion", and "similar to a spaceship with a tail, like the one of a comet"!

The object flew right over La Silla around local time 23^h20^m, and was seen by many of the observers and night assistants. The following description was compiled from the testimonies of several of them; all times are in the morning of January 24, 1992:

2^h15^m UT: (i.e. 23^h15^m local time): A small luminous ring with diameter about 0.5° is seen at west-south-west, 25 degrees over the horizon, moving slowly northward.

2^h15^m–2^h20^m UT: A small, sharp and bright object moves slowly, the ring expands to 5° in diameter, and a huge cone (40° long, 20° wide) follows the object.

2^h20^m–2^h21^m UT: it suddenly accelerates and moves rapidly to the west-north-west, 45° above the horizon. The main object becomes very bright (brighter than Venus!), remains sharp, and is surrounded by a small (1/4°–1/3°) ring (as seen with binoculars). It then becomes more and more diffuse and finally very quickly fades away.

Eric Aubourg, observer at the GPO (Brown Dwarf Experiment), had the good sense to take pictures of the phenomenon. The two exposures are shown in Figure 1 and 2. Even though we have until now no "official" confirma-

Figure 1: *10-second exposure around 23^h18^m (LT), on a TMax 400 film with a Leica camera, 35-mm lens, by E. Aubourg. This is an enlarged part of the negative. The object is seen, surrounded by the ring which is elongated by the motion during the exposure, and is followed by the cone.*

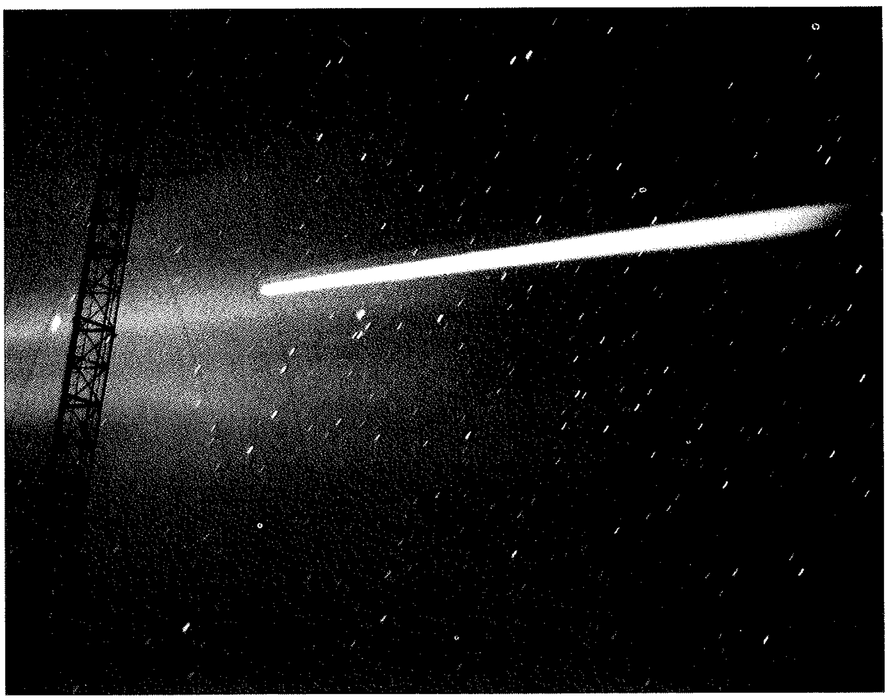


Figure 2: *1-minute exposure from 23^h20^m–21^m (LT) with the same technical parameters. This, however, is a print of the entire negative. To the left the remains of the cone are seen. To the right, the object is fading away and finally disappears.*

tion, this really looks like a satellite or the upper stage of a rocket re-entering the atmosphere. From the trajectory, it would appear that it was the re-entry of the 3rd stage of a rocket launched from the Baikonur Space Center.

Such an event has been seen several times before in Chile, even though it was never watched by so many people. The rocket is launched towards south-east, in order to benefit from the Earth's rotation. The satellite is then released, and the upper rocket stage continues south. It then reaches the southernmost point of its orbit and moves back northward, and finally burns when it re-enters the upper layers of the atmosphere. Because of the relative geographical positions of Baikonur and Chile, this last part of the trajectory may be close to the Chilean shores.

A Near Miss?

In the early morning of January 26, after a night of observations at the ESO 50-cm telescope, we left the dome and stopped to have a look at the beautiful dawn in the eastern sky over the Andean mountains. We were trying to find all the planets visible in that part of the sky. It was indeed a very nice constellation: the Moon, Venus, Mars, Ceres, Uranus and Neptune were all within a few degrees of each other; the technical term for this is a *syzygy*. Mercury and Saturn were also in that region, but they were too close to the Sun to be visible.

It was Alain who first noticed a bright, diffuse object in the south-east direction. It was moving towards north, about 15° over the horizon. We could follow it during about three minutes, then it was no longer visible as the morning sky became brighter and brighter. During that short time, it had moved over an arc of ~20° in the sky!

We checked the appearance of the object through 7×50 binoculars; it had a bright condensation of magnitude ~1, surrounded by a 2° wide, circular nebulosity. Indeed, it looked completely different from a satellite or an airplane: it was much more like a comet. We took some photos of the object and one of them is reproduced here; due to its quite fast motion, it appears like a long trail.

From the observed form and brightness, we feel rather sure that this was not a usual artificial object, like a high-flying aircraft plane or a satellite (it was too bright and diffuse), nor a meteor (for this it was much too slow). From time to time there are some Barium and Lithium release experiments in the magnetosphere which may have this comet-like aspect (IAUC 5154, 5179), but they are normally even brighter. We checked with the coordination office for these experiments and learned that no release was planned for that period.

Even though the most reasonable explanation is that this was a man-made phenomenon, say, a satellite re-entering the upper atmosphere, it cannot be excluded that it had a natural origin. For instance, if a very small cometary nucleus passed very close to the Earth, it might have this appearance. In 1916 – long before there were any airplanes and experiments in the high atmosphere, a comet-like object moving around 10° during one night was observed by Perrine and Glancy (private communication from Brian Marsden). Maybe this was the same kind of object. There may have been other similar events of which we are not aware. We are of course also reminded about the Tunguska event in 1908, which may possibly have been caused by a small cometary nucleus entering the atmosphere, and exploding before it reached the ground.

Weighing all the facts, we are most inclined to believe that what we observed was actually a natural object, passing very near the Earth, although we would not entirely exclude that it may have had an artificial origin. But whatever it was, this experience was certainly interesting and unusual!

A. SMETTE and O. HAINAUT, ESO-La Silla

Figure 1: *The fast-moving "comet-like" object, seen from La Silla in the morning of January 26, 1992 (9^h05^m UT), photographed with a 200-mm objective on 35-mm Fuji 400 ASA colour negative film. Its very diffuse, faint trail is seen passing just above the planet Mars, above the eastern horizon. The motion during the 20-second exposure was about 2°. Reproduction and contrast enhancement by H.-H. Heyer, ESO-Garching.*

The Future of Astronomy Publications: Electronic Publishing?

J. LEQUEUX, Editor-in-Chief, Astronomy and Astrophysics, Observatoire de Meudon, France

Everyone will acknowledge that the present situation of publication of primary journals (i.e. those journals presenting original scientific results) is far from satisfactory. Journals are expensive, cumbersome and slow to come. They contain a lot of information of little interest for a particular scientist, and the information he or she is really interested in is difficult to retrieve. A general opinion seems to be that, in spite of the advantages of the journals in their present paper form, a radical change is needed and will undoubtedly occur in the near future. Electronic publication is obviously the way to go; however we only start to imagine what it could be in practice, and there are certainly pitfalls to avoid. As I will show, astronomers will presumably be amongst the first to lead the way in this mutation. While this may be satisfactory for our proper pride, being a guinea pig is never comfortable: we will also be amongst the first to fall in the pit if we are not careful enough. We must consider the problem very seriously and think very hard, first on what we want and second on the way of achieving it.

For me the story started very recently. The opportunity was the colloquium entitled "Desk-Top Publishing in Astronomy and Space Sciences" held in Strasbourg on October 1–3, 1991. The chairman of the Scientific Organizing Committee, André Heck, asked me to present a review on the experience of *Astronomy and Astrophysics* and other astronomy journals with desktop publishing (desktop publishing means the preparation by the authors of manuscripts ready to publish, or almost so). Then I realized that desktop publishing was in fact a necessary (although not sufficient) step toward electronic publication and I started thinking hard about the future and devoted a part of my talk to it. Several editors and publishers of major journals in astronomy who where present at the meeting shared their views, and discovered that some of them were already engaged in experiments relevant to electronic publishing. After the meeting, we had no difficulty to convince the newly-born European Astronomical Society (EAS) that it was necessary to start an immediate action in Europe. We are presently forming a small group of reflection with the purpose of posing the problems, of discussing them with the astronomical community, and ultimately of recommending actions to the journals. We will have a discussion on the point at the Liège meeting of the EAS on June 22–24, 1992. All this will be made in coordination with the American Astronomical Society (AAS) which is already very active.

Publication and dissemination of their results are certainly amongst the major centres of interest of astronomers, and of scientists in general. This is why I consider that they must start thinking *now* about electronic publication and discussing the related problems between them, with the librarians and with other people. The present paper is a simple introduction. For more details, one should refer to the proceedings of the Strasbourg Colloquium "Desk-Top Publishing in Astronomy and Space Sciences", ed A. Heck, World Scientific, Singapore, to be published in March 1992 (of course a good deal of what I will say now is extracted from my review at this colloquium). Another good reading is the special issue of September 1991 of *Scientific American* on Communications, Computers and Networks, a subject central to electronic publication.

The Present Situation

The present situation with journal publication in astronomy can be summarized as follows:

– All journals are published on paper and distributed by normal mail.

– Microfiche or microfilm editions of some journals (*Astrophysical Journal* and its Supplement Series, *Astronomical Journal*) are also distributed. Microfiches are also sometimes used (mainly by *Monthly Notices of the Royal Astronomical Society* and by *Astronomy and Astrophysics Supplement Series*) for presenting large amounts of data. These supports, although relatively inexpensive, are not particularly favoured by the authors and the users, and their long-term behaviour is uncertain.

– Large data bases submitted to *Astronomy and Astrophysics (A&A)* are often written on magnetic tape and deposited at the Centre de Données de Strasbourg which distributes them on request: in this case the corresponding paper contains only the text and a sample of the table(s). Other sets of data are distributed on tape or on other digital supports with or without reference to a journal, i.e. with or without refereeing.

– Camera-ready papers are accepted by many journals: for example all the Letters to *A&A* are produced camera-ready. Also, camera-ready tables are often inserted in typeset papers. The cost is low and the publication can be fast, but the Editors and the Publishers have no *a posteriori* control on the product which may look inhomogeneous.

– Papers prepared in electronic form by the authors are increasingly accepted by astronomy journals. Bypassing the typesetting stage is obviously the goal of most journals, which recommend the authors to send their manuscripts in digital form, either on some kind of digital support or via electronic mail. A text with an unelaborated style can be supplied by the author and then edited at the editor's or at the publisher's office, or the author can send a text prepared using macros supplied by the journal so that it will have exactly the style and sometimes even the page setting of the journal and can feed with a minimum of interventions the printer's computer.

Most journals use the first level. For this, TEX (and LaTEX) has become a standard for astronomy journal publications, because of its permanence, independence on hardware and possibility of e-mail transmission. *A&A*, its Supplements and a few other journals use the second level. Macros are supplied to the author based on TEX or LaTEX with which he prepares his text. In the case of *A&A* (Main Journal), the author also receives a simulation of the fonts used at the printer's plant. In this level, more work is required from the author. Moreover, page setting will always be better done by professionals, and at present has often to be redone by Springer-Verlag: this may not be the best solution for the future. In spite of this, the experiment is a success: about 30 % of the papers in *A&A Main Journal* are produced by the author using the publisher's macro packages, and the increase has been very fast. *A&A* is the most advanced astronomy journal in this respect. However the situation is rapidly evolving and within one or two years most journals will take papers prepared in one of the two levels of electronic form.

It should be realized that astronomers are somewhat more advanced in the use of desktop publication than the bulk of their scientific colleagues, with the noticeable exception of mathematicians who currently use $\mathrm{T_EX}$ to prepare papers camera-ready or on diskette. Also, astronomers are more advanced than most other scientist in the use of electronic mail for communication between them or even for sending drafts or finished papers in ASCII or $\mathrm{T_EX}$. Astronomers form a well-united, relatively small community. For all these reasons, they will probably be amongst the first to turn to pure electronic publication (not really the first! I recently heard about a purely electronic journal launched by the American Association for the Advancement of Science).

Astronomy Journals on Paper?

It is clear to everyone that journals on paper have considerable inconveniences:

– They are expensive.

– They take room on our shelves; rather than money, this seems to be the reason for the continuous decrease in the number of individual subscriptions to all the major astronomy journals.

– Only a relatively small part of the information is usefull to an individual astronomer. This drawback could be avoided by multiplying the journals which would then be more specialized, or by distributing to individuals only extracts (sections) of the present journals. Multiplication of journals is certainly not the way to go. As to distribution of sections of journals only, it would certainly limit the room taken by scientific literature, but would induce a regrettable further specialization of scientists.

– Information retrieval is difficult. At present, the only practical way to retrieve information is through the indexes, which are quite limited. It is possible to retrieve the bibliography on an individual object by interrogating the SIMBAD data base, but this information has had to be introduced manually into SIMBAD through painful systematic eye searches in all the published papers!

However, paper journals have also definite advantages:

– For the moment, I consider them as the only possible support for long-term archiving. Constant (and unavoidable) changes in computer standards are such that there is nothing like an acknowledged *permanent* digital support of information for archiving. Think for example of what would have happened if we had archived the journals twenty years ago on punched cards, or ten years ago on 1600 bpi magnetic tapes that no one is able to read at present! It is certainly possible to update the digital supports in order to maintain the journals data base, but this requires strong organization and money.

– Authors like to see themselves in print! This is obviously linked to the magic of writing, but also to the previous point: authors fear that their work may not survive if on other supports.

– Paper journals provide immediate access to good-quality information: the eye is a fantastic two-dimensional scanning device.

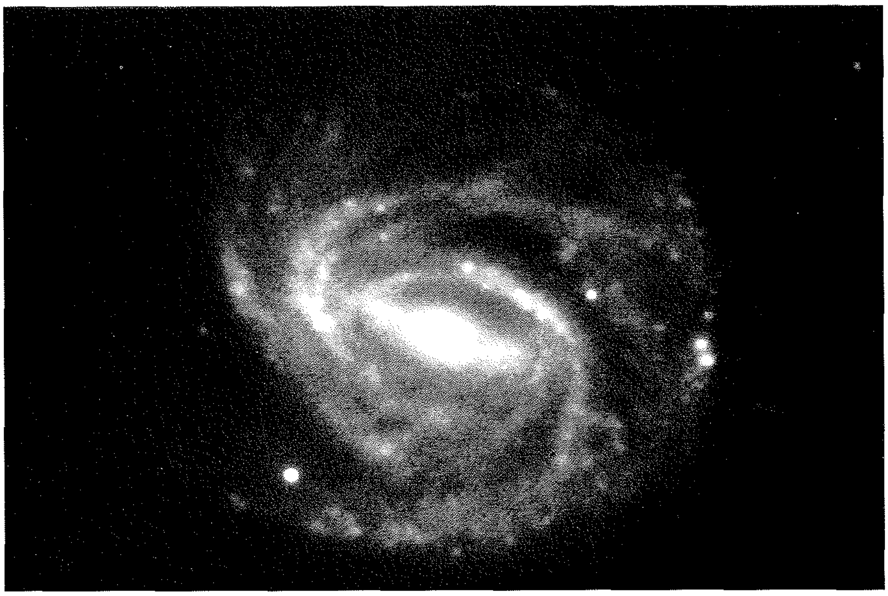
– Browsing through paper journals allows to discover things outside our immediate field of research (the next paper is often more interesting): this is capital to avoid excessive specialization and to fertilize your own research with serendipitous, unexpected material.

However, it is clear that in spite of these advantages paper publication is not the way of the future: we have to face seriously electronic publication. Before going into some detail about the possibilities, it is interesting to give general guidelines.

– The main purpose of scientific journals is to archive the results of research in the best possible way, and to give the easiest possible access to this information. The refereeing system is the best we have found to insure quality and it should be kept whatever the way the journals are produced. Unrefereed preprints are circulating and will always circulate, yet they are very unevenly distributed, their quality is not guaranteed and they are unsuitable for archiving.

– I strongly believe that a printed ver-

Supernova Discovered at ESO



This photo shows the newly discovered Supernova 1992C in the barred spiral galaxy NGC 3367. The supernova is the bright, star-like object in the lower left area (southeast of the centre of the galaxy), at the tip of a spiral arm. Most of the other point-like objects are interstellar nebulae in this galaxy, whose distance is estimated at about 60 Mpc (200 million light-years).

The 16.5-magnitude supernova was discovered by ESO astronomer Hans van Winckel on January 28, 1992. He found it on a photographic plate obtained by Guido Pizarro during a search programme carried out with the ESO 1-metre Schmidt telescope at La Silla. The present photo was reproduced from a 1-minute CCD exposure in visual light obtained by Massimo Della Valle and van Winckel on January 30, 1992, with the ESO/MPI 2.2-metre telescope at La Silla.

Spectra of the supernova, obtained by Della Valle and Christopher Waelkens (Astronomical Institute of Leuven, Belgium), also with the 2.2-metre telescope, show it to be of type II and that the explosion must have happened between 10 and 20 days earlier. This means that it probably was a relatively young, heavy star that exploded. The expansion velocity was measured at about 7000 km/sec.

SN 1992C is the third supernova to be discovered in 1992. Another supernova (1986A) was found on February 4, 1986 in this galaxy, near the condensations in the spiral arms immediately above (north of) the present supernova and to the left (east) of the centre of the galaxy.

The photo covers a sky area of 156×106 arcseconds; north is up and east to the left.

sion will remain necessary for many years, at least in the main libraries. As such a version is expensive to produce, no substantial cost savings are to be expected for the moment. Even if a digital support is ultimately chosen for archiving, permanent update and maintenance of the archive will be necessary and will be costly.

– Electronic publication should be oriented towards an optimization of information retrieval: this retrieval must be as easy and rapid as possible. In particular, access to interesting papers must be immediate, including drawings and half-tones. NASA is starting a programme named STELAR (for Study of Electronic Literature for Astronomical Research) in which they will scan and put on digital form the years 1986–1990 of the AAS publications, and hopefully of European journals as well, and let a group of volontary astronomers make experiments in information retrieval using commercial or their own software packages. This programme, that our study group will watch closely, will certainly be determinant for the future of electronic publication.

There are two types of possibilities for electronic journals:

– journals accessible via computer networks ("e-mail journals");

– journals distributed on some individual digital support.

E-Mail Journals

The fast development of communication networks makes this solution very attractive. Technically it is fully possible at present for text and drawings, although the transmission of half-tones is still problematic and rather slow for the general customer. Reading an e-mail journal requires on-line decoding e.g. of a text produced in $\TeX$ (the obvious standard at least in the immediate future), and of the figures for which a standard remains to be established. For the moment, these operations are slow and cumbersome, especially for figures, but this will certainly improve fast. It is likely that at least for some time the scientist interested in a paper will first print it out. This will be costly, but it may be that ultimately we will be so well acquainted with electronic displays (of high quality, I presume) that this stage can be skipped.

I cannot foresee any problem with the refereeing procedure: all the exchange between author, editor and referee involving paper can be made electronically. However, difficult problems with copyright and recovery of publication costs should be addressed amongst others. One problem that will probably remain for a rather long time is the intermittent difficulty of access due to network and computer crowding. Also, you will not be able for some time to consult your favorite journal in the train or in the plane, unless you have in advance printed or copied on an individual digital support the papers your are interested in. Finally, this solution is unfair to developing countries or isolated places that are still outside the main communication networks; but this will not last for long, probably.

Journals Distributed on Individual Digital Support

In principle this solution avoids most of the problems just discussed with e-mail publication. However, it has its own problems, which are so severe that I have the feeling that it will not make it for the future. For example, it requires that you have on your personal computer a sophisticated reading software and also a screen good enough for a nice

VACANCIES ON LA SILLA

STAFF ASTRONOMER

A position of staff astronomer will become available on La Silla in the second half of 1992. This position is open to experienced astronomers with a Ph.D. degree or equivalent and several years of post-doctoral experience in the area of infrared imaging and/or spectroscopy using array detectors.

The successful applicant will integrate the IR group on La Silla and will share the responsibility of operating the infrared cameras and the infrared spectrograph (IRSPEC). This includes:

- introducing visitors to the use of the equipment,
- writing and updating User's Manuals,
- developing and upgrading data-reduction packages,
- regularly testing the performance of the equipment, and
- interacting with the technical staff regarding modifications and updates of the instrumentation and the control software.

As members of the Astronomy Support Department on La Silla, staff astronomers are required to spend at least 50% of their time on support activities and the remainder conducting original research and participating in academic activities. The Astronomy Group on La Silla is composed of about 20 astronomers including staff, post-doctoral fellows and research students.

Staff posts are tenure track positions, normally offered for an initial period of 3 years that may be renewed for a second period of 3 years. Tenure may be granted during the second term of the staff contract.

The successful applicant will have an excellent opportunity of participating in the commissioning phases of the VLT.

Applications should be submitted to ESO Personnel Administration and General Services at ESO-Garching **before 31 May 1992.**

FELLOWSHIP

A post-doctoral fellowship is offered on La Silla starting during the second half of 1992. This position is opened to a young astronomer with an interest in stellar photometry. Experience in CCD photometry in crowded field will be an advantage. The ESO fellowships are granted for a period of one year, normally renewed for a second and exceptionally for a third year.

The successful applicant will be required to spend 50% of his/her time doing support activities and 50% of the time on research.

Applicants normally should have a doctorate awarded in recent years. Applications should be submitted to ESO **not later than 15 May 1992.** Applicants will be notified by June 1992. The ESO Fellowship Application Form should be used and be accompanied by a list of publications. In addition, three letters of recommendation should be obtained from persons familiar with the scientific work of the applicant. These letters should reach ESO **not later than 15 May 1992.**

The research interests of the members of the staff in the Astronomy Support Department include low-mass star formation, formation and evolution of massive stars and starbursts, post-AGB stellar evolution and planetary nebulae, supernovae, active nuclei, high redshift galaxies and galaxy clusters. Staff members and senior fellows act as co-supervisors for students of European universities that spend up to 2 years on La Silla working towards a doctoral dissertation.

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

European Southern Observatory
Fellowship Programme
Karl-Schwarzschild-Straße 2
D-8046 Garching b. München
Germany

display especially of half-tones. Also, the enormous amount of information that can be stored e.g. on a CD-ROM may tend to induce a less frequent distribution. But the worse problem is with the lack of standardization of the hardware and software, a problem which seems inescapable due to obvious commercial reasons over which we have absolutely no handle: can it be solved at all?

Conclusion

While most astronomy journals are rapidly evolving towards publication of papers prepared by the authors in electronic form, they are still printed on paper. This cannot last for very long, although paper copies will probably remain necessary at least for some time for archiving in the main libraries. Authors, editors and publishers have to start thinking seriously about future ways of publication of journals in electronic form. Fortunately we are still able to master the solutions. We in Europe are just starting an active reflection, which to my opinion should be independent initially from that of our American colleagues because the problems are different, the European journals being mainly commercial enterprises. It is clear that very soon the reflection and the corresponding actions will become organized worldwide, thanks to the excellent cooperation between the Editors of the major astronomy journals. I am confident that when we will decide to turn actually to electronic publication, we will agree on common principles and standards for the benefit of the whole astronomy community. But as a preliminary and necessary step, we need to know the opinion of the future customer. This is why I have written this paper: I hope to receive soon many comments and propositions which are necessary to feed our reflections and to avoid doing bad mistakes.

I wish to thank André Heck for his interest and for interesting discussions and criticisms.

Astronomy Acknowledgements Index 1991

D.A. VERNER, ESO and Space Research Institute, Moscow, Russia

Every astronomer knows that ordinarily many people (not only the authors of the resulting paper) contribute to a scientific research project. It is not necessary to say how important it is to discuss a work with colleagues, to get a good advice or criticism, to receive data prior to publication, etc. Almost all astronomical papers include, in addition to a list of references, a list of acknowledgements. But very often we overlook this section of the paper, where names are usually hidden among numbers of grants.

Table 1: *General statistics of AAI-1991. N_{pap} is the number of papers, N_{ack} the number of acknowledgements.*

	ApJ	*ApJS*	*A&A*	*A&AS*	*MNRAS*	*AJ*	*Nat*	Total
N_{pap}	1635	90	977	169	544	368	102	3885
N_{ack}	5203	393	2377	419	1282	1388	313	11375
N_{ack}/N_{pap}	3.18	4.37	2.43	2.48	2.36	3.77	3.07	2.93

Looking through the leading astronomical journals in 1991, I have compiled an *Astronomy Acknowledgements Index*, which contains references to all personal acknowledgements from the *Astrophysical Journal* (including *Letters*), the *Astrophysical Journal Supplement Series, Astronomy and Astrophy-*

Table 2: *The 21 most-acknowledged scientists from astronomy and astrophysics journals in 1991.*

Name	Affiliation	ApJ	ApJS	A&A	A&AS	MNRAS	AJ	Nat	Total
J. J. Binney	Theoretical Physics, Oxford University, UK	7		2		6			15
R. D. Blandford	California Institute of Technology, Pasadena, USA	15		2		1	1	1	20
P. T. de Zeeuw	Sterrenwacht Leiden, Netherlands	5		2		7	1		15
B.T. Draine	Princeton University Observatory, USA	14	1			2		1	18
A. C. Fabian	Institute of Astronomy, University of Cambridge, UK	6		1		8			15
G. J. Ferland	Ohio State University, Columbus, USA	15				1	1		17
J. E. Gunn	Princeton University Observatory, USA	10				2	4		16
J. W. Harvey	National Solar Observatory, NOAO, Tucson, USA	11		2				3	16
J. P. Huchra	Harvard-Smithsonian Center for Astrophysics, Cambridge, USA	4	3	2	1	4	4	2	20
R. L. Kurucz	Harvard-Smithsonian Center for Astrophysics, Cambridge, USA	12	1	2		1	5		21
J. P. Ostriker	Princeton University Observatory, USA	17	1			2	1	2	23
B. Paczyński	Princeton University Observatory, USA	13		3	1	3	1	1	22
B. E. G. Pagel	NORDITA, Copenhagen, Denmark	5		4	1	6			16
J. E. Pringle	Astrophysics Division, Space Sciences Department of ESA	12		1		1	1		15
J. C. Raymond	Harvard-Smithsonian Center for Astrophysics, Cambridge, USA	13		2		1	2		18
M. J. Rees	Institute of Astronomy, University of Cambridge, UK	6		1		9		2	18
F. H. Shu	University of California, Berkeley, USA	15	1	2			1		19
S. Tremaine	CITA, University of Toronto, Canada	14				7	1		22
S. D. M. White	Institute of Astronomy, University of Cambridge, UK	12				8	1		21
R. Wielebinski	Max-Planck-Institut für Radioastronomie, Bonn, Germany			9	4	2			15
S. E. Woosley	University of California, Santa Cruz, USA	10	1	6			2		19

sics, Astronomy and Astrophysics Supplement Series, Monthly Notices of the Royal Astronomical Society, the *Astronomical Journal*, and from *Nature*'s astronomical articles and letters. The *Astronomy Acknowledgement Index* (AAI) is original and does not overlap with the *Science Citation Index* (SCI). AAI-1991 includes 11,375 personal acknowledgements to 5605 people. (The last number probably is not exact. I have tried to take into account different combinations of first names and initials, but I cannot be sure that it has been done in all cases. On the other hand, namesakes are possible.) Acknowledgements are going to colleagues and referees, students and supervisors, telescope operators and software engineers, directors of observatories and institutes, wives and husbands, parents and friends, etc, etc. All of these people contributed their efforts to Astronomy.

Statistical studies based on SCI (Garfield, 1977, 1985, Abt, 1980, 1981, 1983, 1984a, b, 1987, Rao and Vahia, 1984, 1986, Trimble, 1986) have discovered many interesting features of the astronomical science development. A list of 22 most-cited papers from astronomy and astrophysics journals covered in the 1945–1954 SCI cumulation was published and discussed by Brush (1990). Note that citation counts are not direct indicators of the importance of papers (see, e.g., conclusions made by Leydesdorff and Amsterdamska, 1990).

The statistical analysis of AAI can give us useful additional information and throw light upon another aspect of the scientific process in astronomy. Table 1 shows the general statistics of AAI-1991. Table 2 includes the names of the 21 most-acknowledged persons (in alphabetical order) in 1991. All of them are well-known scientists, who are working in large astronomical centres with an active scientific life. Undoubtedly, they are very communicable people. Most of the gratitudes (79 %) were expressed to them for useful discussions and comments. Other thanks (23 %) were due to providing of data, theoretical models, and computer codes.

Table 2 reflects some advantage of American scientists. However, it should be taken into account that as a rule American papers include more acknowledgements than European ones (on the average, 3.34 acknowledgements per paper in the American journals versus 2.45 in the European journals).

The true significance and importance of papers will be determined only after years or even tens of years. On the other hand, they have immediate personal influence on today's scientific life. The count of acknowledgements is an estimator (of course, more or less relative) of this influence.

Acknowledgement

I am indebted to Dr. H.A. Abt for helpful private communication, and to Dr. R. West for valuable suggestions.

Data from AAI-1991 are available upon request (Internet: dverner@eso.org, EARN/Bitnet: dverner@dgaeso51.bitnet). AAI-1992 is being compiled now.

References

Abt H.A., 1980, *PASP* **92**, 249.
Abt H.A., 1981, *PASP* **93**, 207.
Abt H.A., 1983, *PASP* **95**, 113.
Abt H.A., 1984a, *PASP* **96**, 563.
Abt H.A., 1984b, *PASP* **96**, 746.
Abt H.A., 1987, *PASP* **99**, 1329.
Brush S.G., 1990, *Current Contents* **30**, No. 43, 7.
Garfield E., 1977, *Essays of an information scientist: the awards of science and other essays,* Philadelphia: ISI Press, **2**, 120.
Garfield E., 1985, *Essays of an information scientist: the awards of science and other essays,* Philadelphia: ISI Press, **7**, 152.
Leydesdorff L., Amsterdamska O., 1990, *Sci. Technol. Hum. Val.* **15**, Nr. 3, 305.
Rao A.R., Vahia M.N., 1984, *PASP* **96**, 661.
Rao A.R., Vahia M.N., 1986, *PASP* **98**, 511.
Trimble V., 1986, *PASP* **98**, 1347.

On the Life Expectancy of Astronomers

D.B. HERRMANN, Archenhold Observatory, Alt-Treptow/Berlin, Germany

It has, on occasion, been said and proven by prominent singular examples that astronomers enjoy a higher life expectancy than their "normal" compatriots. There have been several attempts to prove this thesis with the use of statistical data. One such example was M. Ebell's survey of the life spans of 233 astronomers using data from the obituaries in the *Astronomical News* from June 1881 till March 1919. Ebell (1) calculated an average life span of 62.6 years – without however having compared the data with that of the general population. He also published the median life span of astronomers from various countries. The impact of this assertation remains shaky however, due to the small number of representative examples used (i.e. in this case only 10 astronomical personalities surveyed) to substantiate his findings.

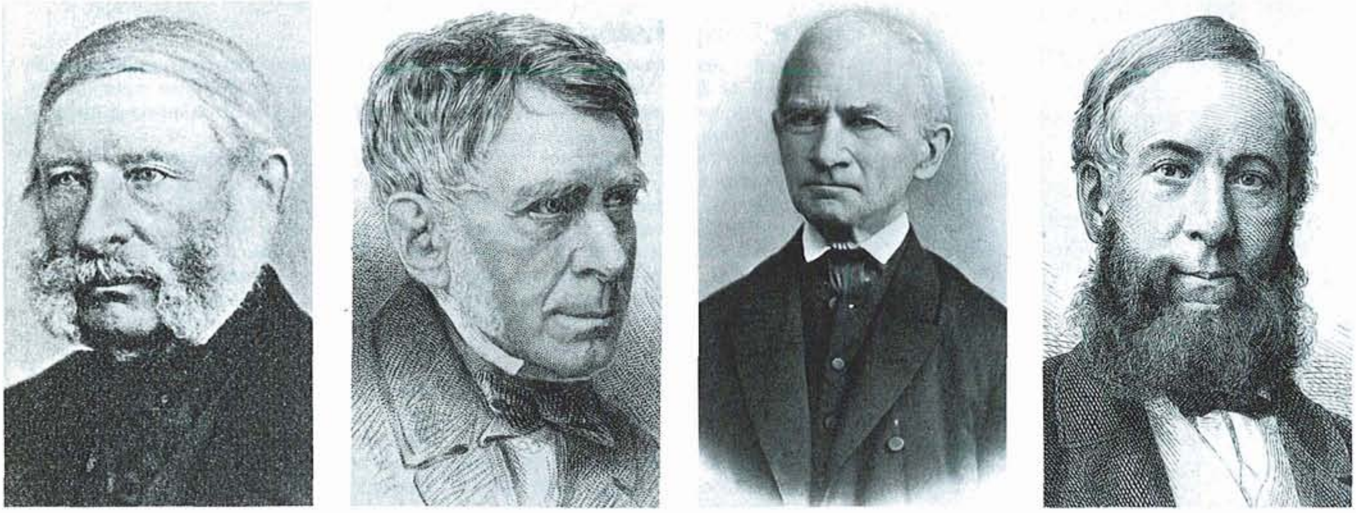
Conversely to Ebell, D.W. Wattenberg (2) used the relevant life span data of 253 deceased astronomers from articles in the *Newcomb-Engelmann* (3) as well as obituaries in the *Vierteljahresschrift der Astronomischen Gesellschaft* and calculated a median life span of 68.7 years for astronomers. Whereby it was noticed by Wattenberg that there seemed to be a distinct rising life expectancy in the course of time, e.g. before 1500: 51.0 yrs.: 16th century: 61.9 yrs.; 17th century: 67.7 yrs.; 18th century: 70.7 yrs.; 19th century: 69.1 yrs. The distribution of these examples over the various time spans and centuries reduced the number of the cases studied to a considerable extent. For the period before 1500 there were only 4 cases, for the 16th and 17th centuries only 16 cases and for the 18th century only 48 persons could be used – statistically seen, rather small numbers.

I was able to also come across a compilation of astronomer's life expectancies from the estate of Johann Heinrich Mädler of Göttingen (4). The data which he used for his work *The History of Astronomy*, lists – without mentioning exact sources and time spans however – the ages of a total of 427 astronomers, for whom he calculated an average life span of 67.8 years.

The impact of these assertions remains unsatisfactory because of the lack of comparison to similar data for the rest of the population. Thanks to the dynamic growth of life expectancy in the industrialized countries, especially from the middle of the 19th century, a clear definition of a period is particularly necessary, as are comparative counts within the general population for the same period under study.

In order to avoid the shortcomings of previous studies, the following study only indicates persons described in my book *The History of Astronomy* (5) and it uses comparative information about the general population (limited however exclusively to Germany) which was deduced from original source material with the greatest care (6).

Since I had access only to data about the general population for the period between 1740–1859, I limited my data to 170 astronomical personalities born between 1715 and 1825, from whom I again selected 67 who began their



Four record holders of life expectancy of recent astronomical history – impressive but not typical. From left to right: J. J. Baeyer (1794–1885, 90.8 years); G. B. Airy (1801–1892, 90.4 years); J. G. Galle (1812–1910, 98.1 years); W. Huggins (1824–1910, 86.3 years).

careers at the age of 25 years. I calculated for them an average life span of 71.6 years. Comparative data for the general population (according to Imhof (6), page 462) indicate a life span of 60.74 years for 25-year-old males. In other words, astronomers seem to reach noticeably higher ages. Even if the criteria for the choice of data are sharpened and only German astronomers are surveyed, out of 33 cases, we get an average life span for astronomers of 69.6 years.

Some Additional Notes are Needed

(1) The use of data on astronomers published in personal registers or biographies implies that only the more famous and successful astronomers are counted. It is much more difficult to say something about all astronomers since the data of the less successful ones are not published anywhere.

(2) The difference in the corresponding life spans and life styles between social stratas of society and indeed between that of astronomers and the rest of the population was surely more pronounced in earlier centuries than it is today. Present-day astronomers are more or less integrated into the community of stress-plagued normal citizens. Thus they probably have the same high life expectancy (FRG 1984/86; 71.5 years for males; 78.1 for females) rates as in other developed countries such as the USA, Australia and other European states (7).

(3) The apparently special role played by astronomers in earlier times is relative. Life expectancies then showed constant high rates of dispersion and social criteria were very decisive factors. Even if the general life expectancy remained on a low level, surely there were other professions and social groups (apart from astronomers) whose life cycles remained generally higher than that of the average person.

100 years ago an astronomer could count on becoming fairly old, but today it is perhaps not quite as worthwhile to choose this arduous profession just to attain this goal. Still, there are exceptions which confirm the rule.

(Translated by R. Guha)

References

1. M. Ebell, Die Lebensdauer der Astronomen. In: *Sirius* **52** (1919), 213–214. I am greatful to D. Fürst for drawing my attention to this source.
2. D. Wattenberg, Das Lebensalter der Astronomen. In: *Die Himmelswelt* **55** (1948), 68–69.
3. Newcomb-Engelmann, *Populäre Astronomie.* 7th edition, Leipzig 1921, p. 801–818.
4. Estate of J. H. Mädler. Niedersächsische Staats- und Universitätsbibliothek Göttingen.
5. D. B. Herrmann, *History of Astronomy from Herschel to Hertzsprung.* Cambridge/England 1984.
6. A. E. Imhof, *Lebenserwartungen in Deutschland vom 17. bis 19. Jahrhundert,* Weinheim 1990.
7. *Ibid,* p. 28.

Pluto and Charon

This drawing of Pluto and Charon was made by Hermann-Michael Hahn, science journalist and physicist in Cologne, Germany, on the basis of the description of the system in the December 1991 issue of the Messenger.

It shows the smaller Charon to the right behind Pluto, exiting the planet's shadow. The brighter area near Pluto's south pole is to the left and the darker north pole to the right.

ESO, the European Southern Observatory, was created in 1962 to . . . establish and operate an astronomical observatory in the southern hemisphere, equipped with powerful instruments, with the aim of furthering and organizing collaboration in astronomy . . . It is supported by eight countries: Belgium, Denmark, France, Germany, Italy, the Netherlands, Sweden and Switzerland. It operates the La Silla observatory in the Atacama desert, 600 km north of Santiago de Chile, at 2,400 m altitude, where fourteen optical telescopes with diameters up to 3.6 m and a 15-m submillimetre radio telescope (SEST) are now in operation. The 3.5-m New Technology Telescope (NTT) became operational in 1990, and a giant telescope (VLT=Very Large Telescope), consisting of four 8-m telescopes (equivalent aperture = 16 m) is under construction. It will be erected on Paranal, a 2,600 m high mountain in northern Chile, approximately 130 km south of the city of Antofagasta. Eight hundred scientists make proposals each year for the use of the telescopes at La Silla. The ESO Headquarters are located in Garching, near Munich, Germany. It is the scientific-technical and administrative centre of ESO where technical development programmes are carried out to provide the La Silla observatory with the most advanced instruments. There are also extensive facilities which enable the scientists to analyze their data. In Europe ESO employs about 150 international Staff members, Fellows and Associates; at La Silla about 40 and, in addition, 150 local Staff members.

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

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ESO's Early History

The recent series of eleven articles about the early history of ESO, written by Professor Adriaan Blaauw, have been collected in a book. The text has been thoroughly revised and includes photos which were not in the *Messenger* articles.

The narrative begins with the developments in the early 1950's when leading European astronomers initiated a search for the best possible observatory site under the comparatively unexplored southern sky. Ten years later, in 1962, ESO was established by an international convention and soon thereafter a remote mountain top in the Chilean Atacama desert, La Silla, was acquired. It took another decade to transform this site into the world's largest optical observatory.

ESO exemplifies the highly successful European integration in a fundamental field of science, providing European scientists with modern facilities for front-line investigations beyond the capacities of the individual member states.

Professor Adriaan Blauuw, well-known Dutch astronomer, has been closely associated with ESO during all of this time. He actively participated in many of the events described and as a former Director General of ESO (1970–74) he possesses first-hand knowledge of the organization and the way it works. A scientist of international renown, Professor Blauuw is also a noted amateur historian in his home country.

The book is available from ESO; the price is 25 DM, which must be prepaid by cheque or bank transfer to ESO account No. 2102002 at the Commerzbank in Munich (BLZ 70040041). Please be sure to indicate "ESO History" in your order.

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