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Bigger Telescopes and Better Instrumentation: Report on the 1992 ESO Conference

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The Conference "Progress in Telescope and Instrumentation Technologies" took place in Garching on April 27–30, 1992. This meeting is one in a series of Conferences organized every other year alternately by Kitt Peak National Observatory and by ESO. The next one should take place in two years in Arizona.

The Conferences organized by ESO have a twofold purpose. First, as a meeting at the worldwide level to present and discuss recent advances in telescopes and instrumentation. Second, for the general ESO community to inform themselves of technological progress both at ESO and other observatories. This Conference was attended by 270 external participants and 69 ESO participants. There were 110 posters and 61 talks.

The first two days were devoted to large telescopes, mirror fabrication, and enclosures (51 posters, 32 talks). Adaptive optics was the subject of the third day. The fourth day saw a review of a number of optical and infrared instruments for the VLT and other telescopes. A brief outline of these topics follows.

1. Telescopes and Mirrors

At the present time thirteen individual telescopes with diameter larger than or equal to 6.5 m are under construction or are planned with various degrees of funding (see Table 1). The total collecting area of these telescopes is 675 m^2 or 70 times that of a 3.5 m telescope.

This shows the intense activity taking place now in all major observatories not only to build these telescopes but also to equip them. Among these groups building large telescopes, the most suc-

Riccardo Giacconi – ESO's Next Director General

In its 67th meeting in Garching on June 4 and 5, 1992 the Council of ESO appointed Prof. Riccardo Giacconi as Director General for the period 1993 – 1997. He succeeds Prof. Harry van der Laan whose five-year term ends this year.

Prof. Giacconi was born in Genova (Italy) in 1931 and got his education in Physics at the University of Milano, before emigrating to the United States. In his activity he has been associated with several leading institutions including Princeton University, American Science and Engineering, Harvard University and has received many honours for his achievements in science.

Prof. Giacconi is famous for his pioneering work in the development and application of X-ray technologies in astronomy, leading to the discovery of the first extra-solar X-ray source. The X-ray satellites UHURU (launched in 1970) and the Einstein Observatory (launched in 1978) are associated with his name.

Since the establishment of the Space Telescope Science Institute in Baltimore in 1981, Prof. Giacconi has been its Director, while holding a professorship at the John Hopkins University and, more recently on a part-time basis, also at the University of Milano. The ST ScI has been central to the Hubble Space Telescope's success in spite of its optical flaw and serves a world-wide community of HST users. At ESO his association with the HST will continue, because ESO Headquarters is the host of the European Coordinating Facility for the HST. The ECF is a joint venture of ESO and the European Space Agency (ESA).

The prime assignment of the new Director General will be the completion of the Very Large Telescope (VLT) Observatory which ESO is constructing with European industry in Chile's Atacama desert, while at the same time operating the world's largest infrared/optical observatory, the La Silla Observatory for the astronomy community in ESO's member states.

Table 1: *Telescopes with diameter larger than or equal to 6.5 m under construction or planned.*

Name	Primary Mirror	Telescope Location
4 telescopes making up the VLT	4 × 8.2 m thin meniscus	Cerro Paranal, Chile
Keck I Keck II	10 m segmented 10 m segmented	Mauna Kea, Hawaii Mauna Kea
Japanese Large National Telescope	8.3 m thin meniscus	Mauna Kea
Gemini	2 × 8 m. Mirror type to be decided	1 on Mauna Kea 1 in Chile (Cerro Pachon)
Columbus	2 × 8.4 m. Mirror type: Borosilicate Honeycomb	Mt. Graham, Arizona
MMT	6.5 m primary to replace the six 1.8 m mirrors. Borosilicate Honeycomb	Mt. Graham, Arizona
Magellan	6.5 m. Borosilicate Honeycomb	Las Campanas, Chile

cessful ones will be those which not only attract excellence and originality of the observing programmes but which will also make the necessary effort to achieve the highest quality and efficiency in the instrumentation and data analysis.

Among the most advanced projects, the installation of the last segmented mirror of the Keck I telescope was announced. The telescope in its present state has a FWHM of 2 arcsec. Work is now in progress to achieve the specification of a final FWHM of 0.4 arcsec. The efforts are twofold: one is to finish the figuring of each segment with an ion beam and the other is to align the 36 individual mirrors. The ion beam finishing consists in erosion of the surface with a computer operated ion beam of a few cm in diameter. This is best used to correct the last surface defects 1 to 2 μ in height. Can this process of automated measurement and computer controlled fine figuring replace the magical final touch of the experienced optician?

Regarding the VLT, it was already announced (*The Messenger* No. **67**, 1992) that the fabrication of the first mirror is well advanced: the 8.6-m blank has been annealed and is now in the process of ceramization, a process to achieve the zero expansion coefficient of Zerodur and which will take 8 months. (Ceramization is roughly speaking a way of partially crystallizing the glass mass by slow and controlled heating. The crystal has a negative coefficient of expansion which can compensate the positive expansion coefficient of a purely glassy material.) The mirror will then be shipped to the REOSC factory near Paris where it will be ground, figured and polished to its 8.2-m diameter size, then shipped to the VLT site. A second 8.6-m blank has also passed the annealing process and a third one is in the annealing oven.

The fabrication of borosilicate honeycomb mirrors is also progressing. Two mirrors, one of 1.8 m and one of 3.5 m have been completely finished. The final figure is 80% of the light within 0.3 arcsec, well within the specification. The first 6.5 m has recently been cast.

The Japanese Large National Telescope will have a thin meniscus which is being fabricated by Corning. The site of the JLNT on Mauna Kea is in a convenient location to do interferometry with this telescope and the two 10-m diameter Keck telescopes. (The Japanese project is called Subaru which means Pleiades, a poetic name which is given to quite a few projects in Japan, especially in the artistic world; for example it is the name of a poetry journal.) The large figure in dollars given for the project is the figure proposed by the astronomers to the funding agencies; it is

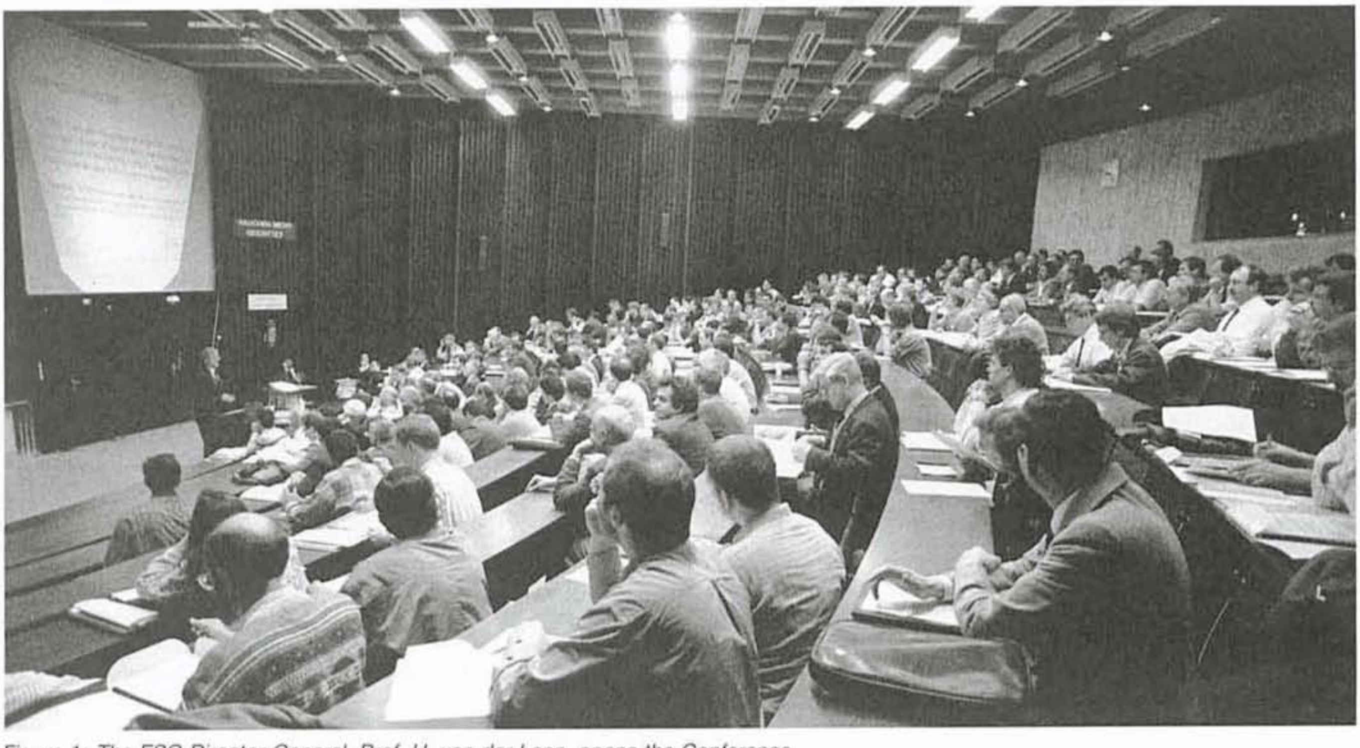

Figure 1: *The ESO Director General, Prof. H. van der Laan, opens the Conference.*

Figure 2: *From the poster gallery.*

a "pessimistic maximum". In contrast, in the Western world the tradition is to start negotiating from a small figure, an "optimistic minimum".

Several methods of producing large (convex) secondary mirrors were presented: active laps, mirror replication and also use of a profilometer to mechanically measure the shape of the surface and compare it to its ideal shape. This latter method has been successfully (specification 100% of light in 0.″15) used to figure the Keck Telescope secondary which is 1.5 m in diameter and for which the maximum aspheric amplitude is 130 μ. The secondary of the VLT is presently planned to be in SiC, a compound which has a density slightly larger than Zerodur but whose Young modulus is ~ 400 gigapascal instead of 70. Because of this quality the mirror can be lighter by a factor ~ 4 than if it were built of glass, and thus achieve the dynamical performance necessary to accomplish the tasks of focusing, centring, image stabilization and especially chopping.

But very interesting developments were also presented for "old telescopes" built several years ago, for example the retrofitting of new technology on the CTIO 4-m telescope by transferring technology developed for the ESO NTT to this "old" 4-m telescope. Specifically, this consists in removing from the dome and building all that could be removed, improving the insulation of unmovable heat sources (pumps for example), improving the ventilation by opening 4-m-high windows in the lower part of the dome walls, refiguring the secondary, and mounting a permanent image analyzer. More ambitious is the plan to modify the primary mirror support and transform it into an active support based on air bags and inexpensive off-the-shelf controllers.

2. Adaptive Optics: Promises and Difficulties

The third day started with a summary of the Second ESO Conference on High Resolution Imaging by Interferometry (*The Messenger* No. **66**, p. 5). The rest of the day was devoted to Adaptive Optics and a poster session. This one is the first of the large European Conferences on ground-based telescopes and instrumentation in which a significant fraction of the programme was set aside for adaptive optics. This reflects firstly the increased realization of the potential importance of adaptive optics as one of the astronomer's tools in ground-based observatories. Secondly a wealth of information has become available from three well-funded US laboratories whose part of their research in adaptive optics has recently been declassified: Lawrence Livermore National Laboratory in California, Phillips Laboratory at Kirtland Air Force Base in New Mexico and Lincoln Laboratory at MIT (Massachusetts). One of the several reasons for this declassification was the rapid progress in the successful use of adaptive optics made in the astronomical context, especially the COME-ON experiment – the Meudon-ESO experiment in collaboration with three French laboratories.

Adaptive optics presents substantial advantages for high-resolution direct imaging, spectroscopy, stellar coronography and long baseline optical/IR interferometry. For direct imaging, adaptive optics is more powerful than speckle interferometry for mapping relatively faint extended objects (e.g. distant galaxies). Regarding high resolution spectroscopy (say R ~ 10^5), adaptive optics will allow one to use a narrow entrance slit. Since for a given high spectral resolution, the linear dimension of the grating is proportional to the entrance slit width, a decrease of the slit width from 1 to 0.25 arcsecond will correspond to a spectrograph with gratings and other optical elements four times smaller. This results in a spectrograph which is less expensive, easier and faster to build, and with less thermal and

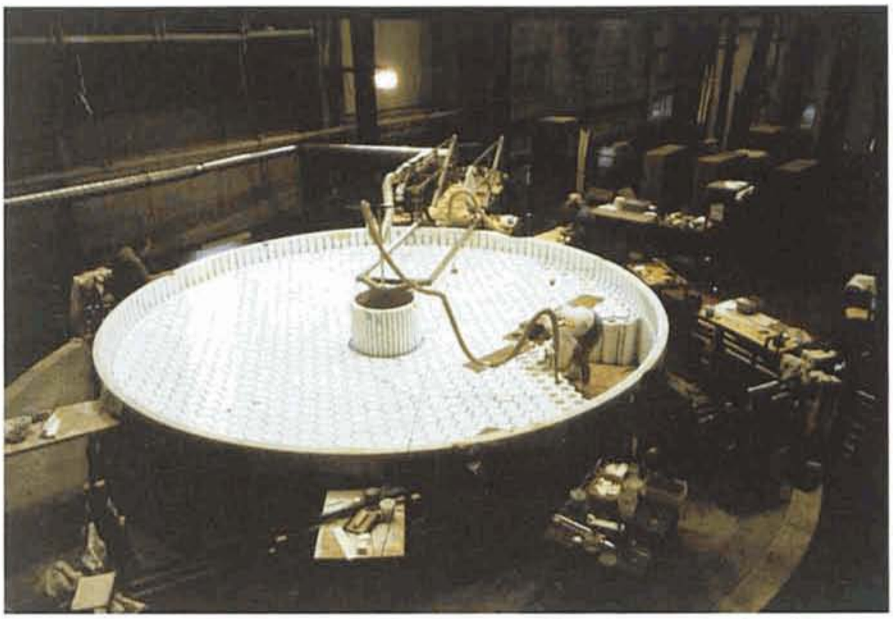

Figure 3: *Preparation for fabricating the first 6.5-m borosilicate honeycomb mirror. The 6.5-m mould under construction. At the time of the Conference, the 6.5-m mirror had already been cast.*

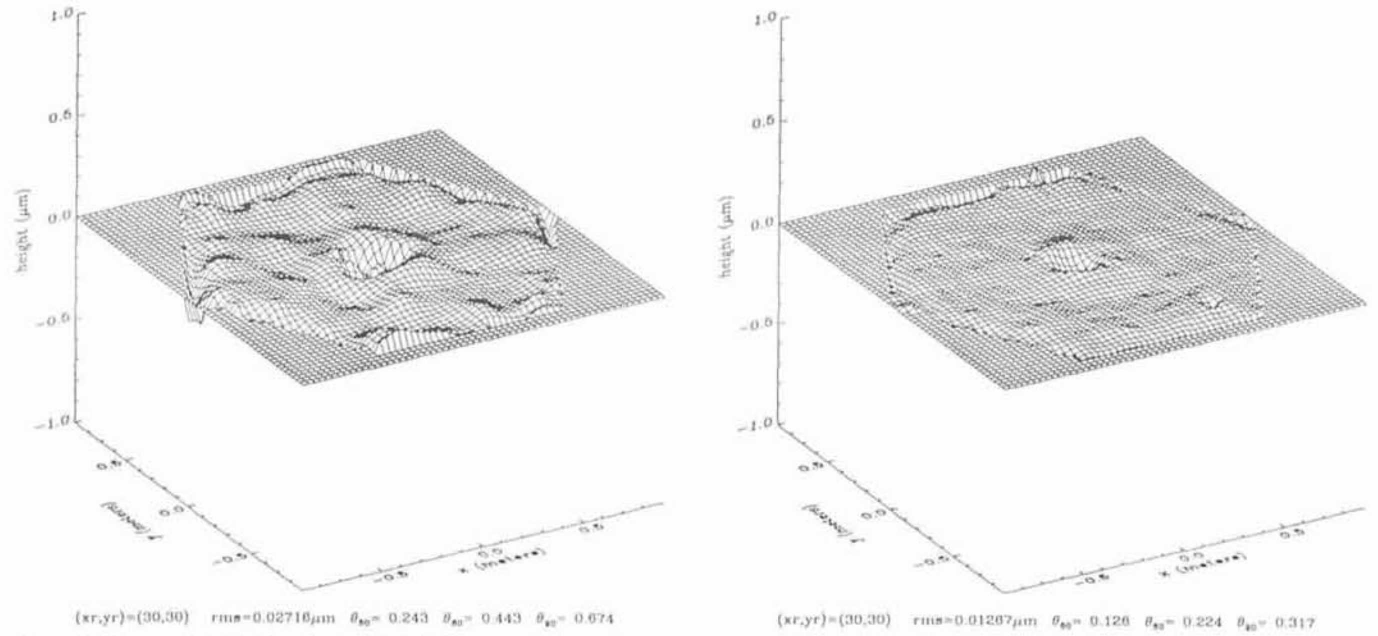

Figure 4: *Segment fabrication for the Keck Telescope 10-m diameter primary. Left: the segment surface with stress mirror polishing and warping harness but before ion beam figuring (80 % of the light in 0.″44). Right: same after ion beam figuring (80 % of the light in 0.″22 which slightly exceeds the specification) (from T. Mast and J. Nelson).*

flexure problems. As far as interferometry is concerned, it is only with a near complete wavefront correction at each telescope that one can achieve the maximum efficiency. This is an important point as the high angular resolution of the interferometer means that the photons of a given source are spread over a large number of independent picture elements. It is clear, therefore, that large collecting apertures and high efficiency must accompany the large angular resolution.

What are the performances of the present adaptive optics system? What are the predictable progress . . . and difficulties? From the 13 oral presenta-

Figure 5: *Synthetic interferogram calculated from the final phase map after stressed-lap polishing of the 3.5 m f/1.5 paraboloid. The measurement was made in December 1991 with a 633 nm phase-measuring interferometer through a refractive null corrector. The rms surface error is 21 nm (from Buddy Martin, Steward Observatory).* ▶

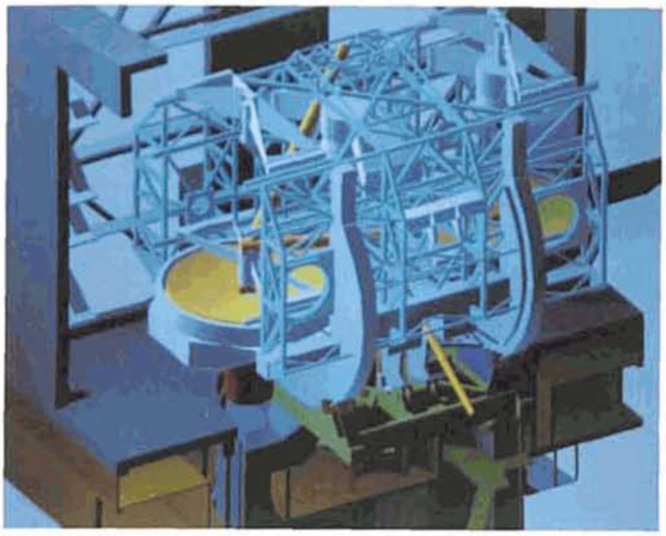

Figure 6: *Computer drawing of the Columbus Telescope (P. Salinari, Arcetri Observatory).*

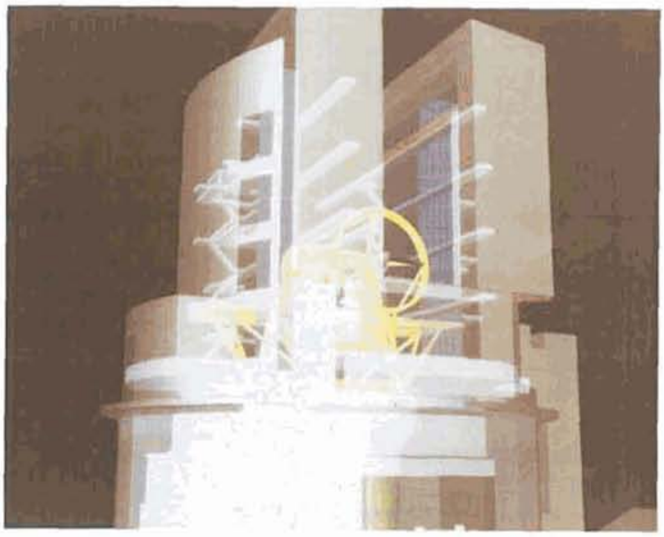

Figure 7: *The Japan National Large Telescope Project (diameter of the primary: 8.3 m). Enclosure concept: there are two large walls ("great walls"), one on either side of the telescope in order to channel and flush the air flow. Front, back, and side ventilators are provided. The enclosure will be air conditioned in the day time (from K. Kodaira, National Astronomical Observatory).*

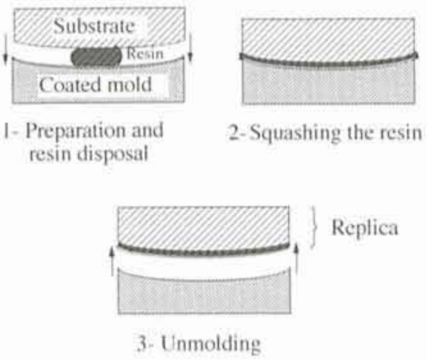

Figure 8: *Making convex surfaces by the replica technique. Prior to making the replica, the mould is coated with a reflecting substrate which at the end covers the external resin surface. The final thickness of the resin layer is 50 μ (from P. Assus, O.C.A.).*

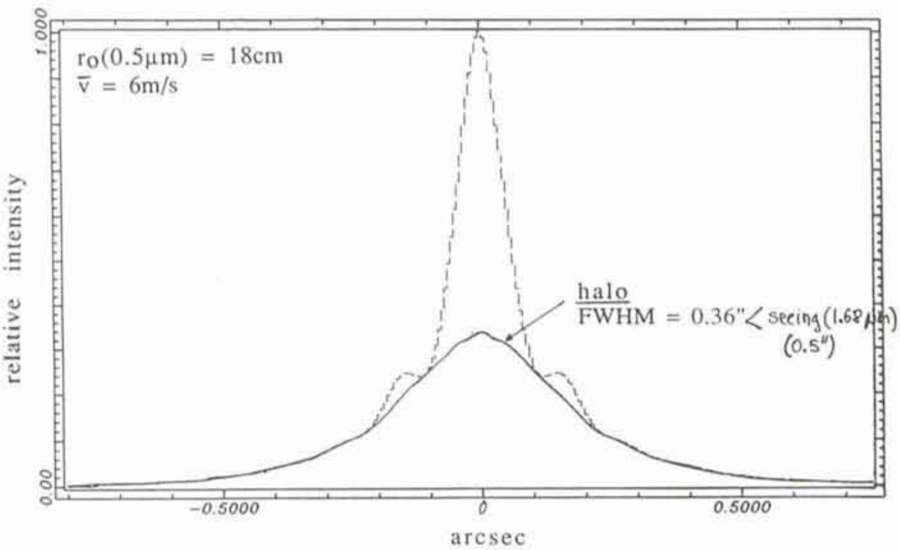

Figure 9: *Experimental PSF at 1.68 μ obtained with the COME-ON system with a seeing of 0."5 with the ESO 3.6-m telescope. The image is composed of a halo (continuous line) of 0."36 FWHM and a sharp core (broken line) which has the width of the Airy pattern of the telescope (F. Rigaut, G. Rousset et al. COME-ON experiment).*

tions and the 26 posters one was able to get a fair assessment of the situation.

There are two parts in an adaptive optics system: one is made up of the wavefront analyzer, the deformable mirror, the detector and the computer. The other one is the reference star.

The first part of the system is well developed: The COME-ON Plus system will have 52 actuators and a correction rate of 400 Hz. The Lincoln Laboratory experiment and the Phillips Laboratory experiment have 241 controlled actuators with wavefront sensing and analyzing performed in 0.5×10^{-3} seconds. These figures lead one to estimate that full wavefront correction is attainable in the foreseeable future at $\lambda \sim 2.2$ μ for an 8-m telescope. The VLT plans an adaptive optics system of 256 elements.

But the problems are severe regarding full correction in the visible (~ 0.55 μ). One needs a faster computer and a larger number of actuators. It is not easy but it is possible to build such a system. The real difficulty lies in the fact that one needs a reference star within the isoplanatic patch of the source to be observed, i.e. within a radius of a few arcsec. And this star must be bright to send enough photons for analyzing the wavefront in less than a few milliseconds. The only way to have such a star everywhere in the sky is to make it – with a laser beam tuned to the 0.589 μ sodium line which produces resonance scattering in the mesospheric atomic sodium layer at an altitude of ~ 90 km. The spot where the laser beam hits the sodium layer forms a point-like source. But a single artificial star is not enough for large telescopes because of focal anisoplanatism (two points diametrically located on an 8-meter diameter mirror see the point source at 90 km at angles differing by 20 arcsec, i.e. larger than the isoplanatic patch). It is proposed therefore to use several laser stars grouped within 10–20 arcseconds, plus a natural star to correct for the tilt. This is, to say the least, an expensive and cumbersome system. In addition, the laser beams produce light pollution which may be a nuisance not only for the telescope working with adaptive optics but for the other telescopes on the same site as well. Stroboscopic shutters and holographic filters could provide protection against such a nuisance but this is not well explored at present. The problem caused by the light pollution produced by the laser stars is less acute in the case of satellite surveillance from the ground than for astronomical observations. Satellites have an optical magnitude of about 15 or brighter while astronomers are interested in mapping much fainter objects as well as bright objects. Astronomers also have more limited funding. They will have to build the adaptive optics systems within the

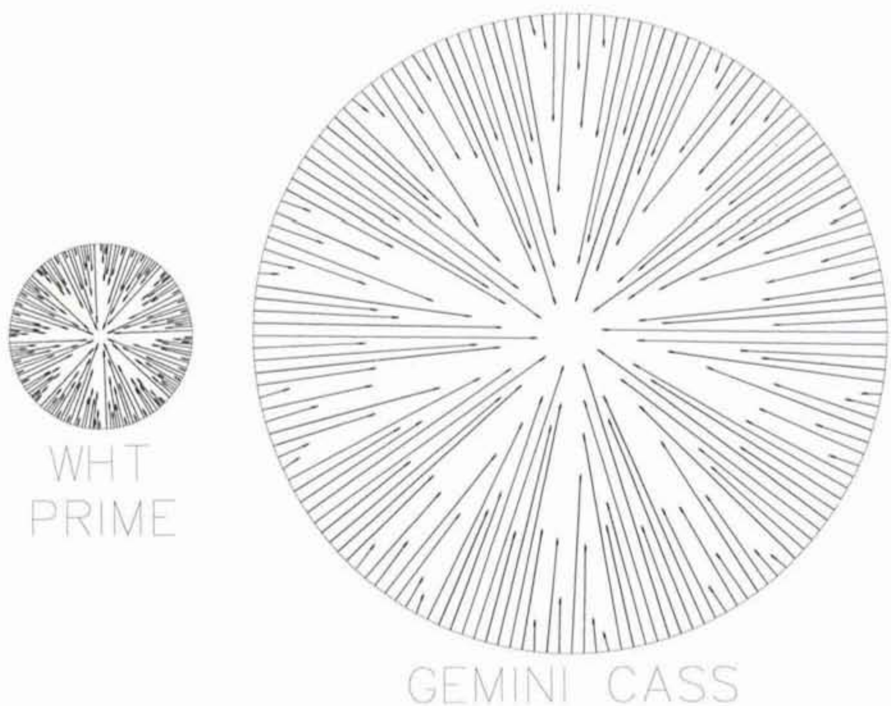

Figure 10: *Multiaperture spectroscopy with optical fibres. The arms positioning the entrance of the optical fibre at the prime focus of the William Herschel Telescope on La Palma (diameter 4 m) and at the Cassegrain focus of one of the planned 8-m telescopes of the Gemini project (drawn to scale) (from I. Parry, Univ. of Durham).*

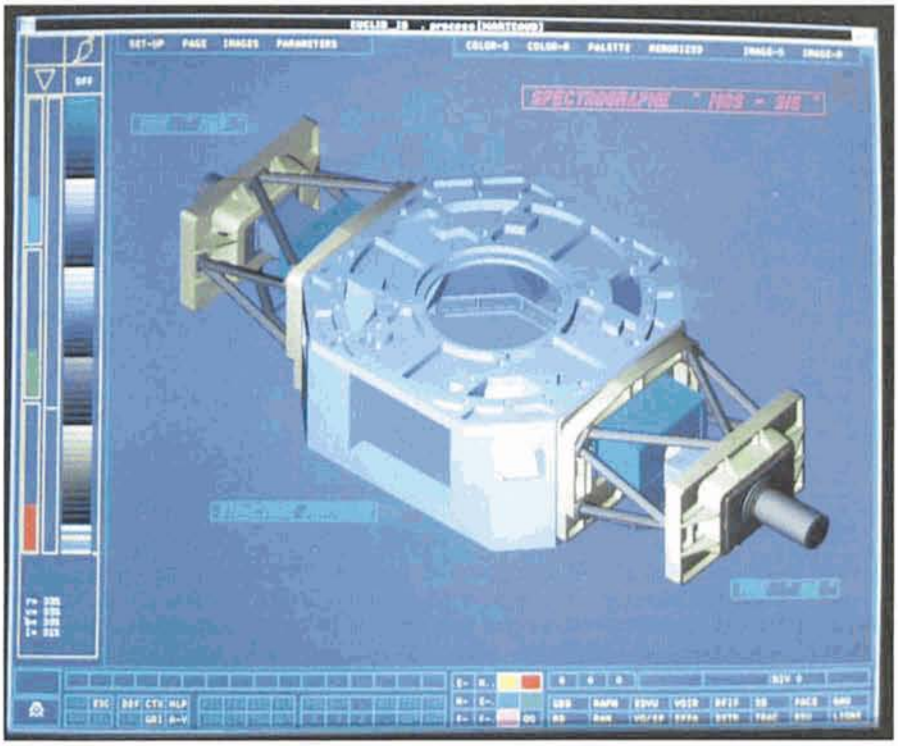

Figure 11: *The Second-Generation CFHT Cassegrain Spectrograph is in reality a double spectrograph. One arm (here at top left) is MOS, a multi-object spectrograph with a 10 arcmin field. The other arm (bottom right) is SIS, a sub-arcsecond imaging spectrograph with a 3 arcmin field.*

resources at their disposal. They will therefore be faced with choices and compromises. These compromises will translate into imperfections of the point spread function (PSF). Among these less than perfect PSF, which ones will be most useful, or best adapted to a particular type of observations? The one with the faintest halo? The narrowest central peak? The maximum strehl ratio? Simulations of observations of different objects with a variety of PSF are a prerequisite to answering these questions. The answer will depend both on the scientific application of adaptive optics and on technical limitations.

3. Instruments and Components

The fourth day of the Conference was devoted to the description of instruments under construction for 4-m class or 8-m class telescopes with a large fraction of the time given to the instrumentation for the VLT. (Six VLT instruments are now in the final design stage – see *The Messenger* **65**, 67.) Present and predicted performances of three types of components were also discussed: optical fibres, CCD and NICMOS detectors.

The two largest groups of instruments represented in the 33 posters and the 16 talks were the faint object spectrographs and the infrared instruments. In the first case, the impetus is given by the current emphasis on cosmological observational programmes and the increasing reliability and sophistication of optical fibres and multislit systems. In the case of the infrared instruments, the impetus comes from the rapid improvement of the performances of infrared detectors, in particular the number of pixels, and the perspective of using the large telescopes at or near their diffraction limit.

While almost all of the telescopes and instrument designs were for multipurpose observations, one project stood out: The Sloan Digital Sky Survey is a 2.5-m telescope (with a 3-degree field of view) whose scientific purpose is to obtain a new sky survey, and to measure optical spectra of 1 million galaxies and quasars selected from this survey with the aim of getting an empirical description of their 3-D distribution (large-scale structure) and their cosmic evolution.

The telescope is devoted to the above astrophysical project and does not have to justify its existence beyond the accomplishment of this project. In that sense, it bears some similarities with the large experiment built around particle accelerators or the older generation of radio telescopes.

A distant cousin and complement of this project is the DEEP, the Deep Extragalactic Evolutionary Probe. This is a spectrograph planned for the Keck Telescope and which will be dedicated to one task: obtaining the redshift and velocity dispersion of 10^4 to 1.5×10^4 faint galaxies of magnitude up to 23 to 24. The spectrograph is in fact made up of 4 identical spectrographs at the Cassegrain focus of the Keck telescope. The spectrographs probe 4 fields disposed symmetrically around the optical axis, the central field being used for TV acquisition and guiding.

Mirror Container and VLT 8.2-m Dummy Mirror Arrive at REOSC Plant

P. DIERICKX and W. ANSORGE, ESO

Within the framework of the VLT primary mirror polishing contract, an 8.2-metre reinforced concrete dummy mirror was manufactured in Dunkirk by SOCOFRAM, REOSC subcontractor for the manufacturing of the dummy mirror, mirror handling tool and transport container.

Although no "first light" is scheduled for this unfortunate brother of the Zerodur mirrors, it is already experiencing the first steps in the life of a real mirror. Indeed, the dummy mirror will serve many purposes:

- test of the mirror handling tool;
- test of the mirror container upon road and river transport and upon handling;
- test of the grinding and polishing machines at REOSC plant;
- tests with the primary mirror cell and structure;
- integration tests in Chile.

The two first steps are now completed. On April 13 it was loaded into the transport container. Figure 1 shows the white-painted concrete mirror being held above the transport container. The curvature of the mirror is clearly visible. Note the 28 dampers (dark plots on the container bottom surface) that will support the mirror and damp the vibrations transmitted by the transport vehicles. The operation was conducted under conditions much tougher than the ones the Zerodur mirror will experience (single hook crane, poor adjustment control), and two trials were necessary to bring the mirror down horizontal and correctly centred. The Zerodur mirrors will be handled with three-hook cranes that allow far better control.

After that vibration sensors were mounted onto the dummy mirror and into the container and the box was closed. The mirror learned patience while endemic strikes in Dunkirk harbour delayed the ship loading, that finally took place on May 21. Lifting a 36-ton 8.4-m diameter box with a single central hook seems quite a challenge. However, crane operations proved much smoother than expected and the container was lowered down into the cargo bay without particular problems.

The ship left Dunkirk on May 22 and headed through the Channel and up the Seine toward Evry, south of Paris. According to the crew, it made quite an impression crossing Paris, river boats being usually much smaller. Last but not least, it's almost active: the whole cabin can be lowered down at the level of the bay roof thus allowing the ship to pass under rather low bridges.

While still in the Channel the crew made tests to feed the vibration sensors with data the (superb) weather was seemingly not decided to provide. Full power manoeuvers back and forwards reportedly did not generate significant vibration levels. While going up the Seine, inevitable shocks occurred at the crossings of locks.

Figure 1: *Dummy mirror being loaded onto the transport container.*

In the morning May 25 the ship was at the dock in Evry, ready to be unloaded with a mobile 200-ton crane. Figure 2 shows the mirror container being unloaded from the ship. With the Zerodur mirrors, dampers will be mounted on the sides of the container to damp possible lateral shocks.

While in Dunkirk a standard truck was used to carry the mirror to the dock, in Evry the type of truck that was selected for the transport of the Zerodur mirrors was used. The key feature is the hydraulic platform that allows a precise control of the container movements. The platform can be driven under the container and lifted up to load the container. In addition, the platform can be tilted by $\pm$ 10° (see roll test shown in Figure 3). In the afternoon further tests were conducted, such as full power acceleration followed by emergency braking, or acceleration while driving over a 6-cm-thick wooden beam (the beam is still ok).

Figure 4 shows the truck at about 10:30 p.m., awaiting its escort after being washed by a light rain. The road transport started at about 0:00 on May 26. Access to the speedway was slightly problematic; a few low branches believed they could stop the progress of science. Actually, they were wrong; mercy for their soul. Figure 5 shows the truck on the access road to the speedway.

The speedway was closed for about half an hour, the time for the truck to drive to the exit that still bears no other mark than "REOSC Optique". The vibration sensors were fed with data while the truck was driving at 5, 10, 15, 20 km/h and for a short time at the race speed of 25 km/h. On the road to REOSC plant, the speed was reduced to walking speed and the flowers of two roundabouts faced a dramatic shortcut of their life expectancy. Upon arrival at REOSC's gate we found a muddy horseshoe that we officially offered to

Figure 2: *Unloading of the ship in Evry.*

Figure 3: *"Rock-and-roll" test on the hydraulic platform.*

Figure 4: *10:30 p.m.: ready to go.*

Figure 5: *00:30 a.m.: on the way to REOSC plant.*

REOSC representatives.

Preliminary observations seem to show that even during the toughest tests, the accelerations experienced were well below the critical values for a Zerodur mirror. This, of course, will have to be confirmed after the data recorded by the vibration sensors will be reduced. That should be done by the end of June.

Introducing the First VLT Instrument Science Teams

J. M. BECKERS, ESO

As described in the *Messenger* **65**, page 10, ESO has embarked on a very ambitious programme of instrument construction for its Very Large Telescope. The simultaneous construction of four 8-metre telescopes with four focus stations each as well as combined foci using incoherent and coherent beam combination result in the need for a relatively large complement of instruments, well exceeding the initial instrumentation requirements of other large telescopes like the Keck telescope. The VLT instruments are being constructed both in-house by the ESO optical and infrared instrumentation groups and by consortia of institutes in ESO member countries. Recently contracts have been signed with a consortium headed by I. Appenzeller from the Landessternwarte in Heidelberg for the construction of two VLT Focal Reducers/Spectrographs (FORS) for the Cassegrain foci of the first and third VLT 8-metre telescopes and with a consortium headed by R. Lenzen from the Max-Planck-Institut für Astronomie, also in Heidelberg, for the construction of the Coudé Near Infrared Camera (CONICA) for the first VLT telescope. These instruments were described in the 67th issue of the *Messenger*. The instruments being built by ESO are the Infrared Spectrograph and Array Camera (ISAAC) for the first VLT telescope and two copies of the Ultraviolet/Visible Echelle Spectrograph (UVES) for the Nasmyth foci of the second and third VLT telescopes.

Both the ISAAC and UVES proposals were reviewed and approved by the ESO Scientific Technical Committee (STC). A number of other instruments are in the definition phase which will lead to proposals for their construction to ESO.

These instruments are common-user instruments being built for the scientific community. They therefore have to be built following high standards of quality, reliability and standardization. ESO has also decided to create for each instrument a team of scientists representing its user community (or "customers"). After the approval of each instrument, either by the signing of the construction contract or by STC approval, such an Instrument Science Team is created. The IST team monitors the implementation of its instrument, concentrating on issues relating to its scientific use. It is asked for its advice on matters relating to this use, and it reports directly to the ESO Director General and the VLT Programme Scientist.

At this moment Instrument Science Teams have been formed for CONICA, FORS and ISAAC. UVES was only approved recently (May 12, 1992) by the STC. Its IST will therefore be created shortly. The membership of the three Instrument Science Teams is as follows:

Coudé Near-Infrared Camera (CONICA)

T. de Jong (Groningen)
C. Perrier (Grenoble)
M.-H. Ulrich (ESO), chair
H. Zinnecker (Würzburg)

Focal Reducer/Spectrograph (FORS)

J. Bergeron (Paris)
S. Cristiani (Padova)
P. Shaver (ESO), chair
J. Surdej (Liège)

Infrared Spectrograph and Array Camera (ISAAC)

R. Chini (Bonn)
G. Miley (Leiden), chair
E. Oliva (Firenze)
J.L. Puget (Orsay)

Each IST has four members. For instruments built by ESO all members are selected from institutes in ESO member countries, for instruments built elsewhere the IST is chaired by a member of the ESO scientific staff. These teams represent the future user community of these instruments. They therefore welcome your input on scientific matters relating to these instruments, as does the VLT Programme Scientist (the author of this note).

PARSCA 92: the Paranal Seeing Campaign

M. SARAZIN, ESO

The fidel readers of the Messenger certainly recall LASSCA 86[1], the La Silla Seeing Campaign which gathered several scientists from the member states with the principal aim of studying the physics of the atmosphere above the observatory. The success of LASSCA significantly increased the confidence that the theory developed during the seventies for modelling the interaction of atmosphere and starlight was adequate for astronomical purposes. It was also a sound starting base for the part of the VLT site survey related to image quality.

The LASSCA group assessed in a first report[2] the general quality of La Silla, identifying the relative contribution of dome, surface layer, boundary layer and high atmosphere in the long exposure width of astronomical images (seeing). They also compared various means of monitoring the atmosphere using large or small telescopes, acoustic sounder and microthermal sensors.

In a second report[3] and several publications[4,5], a first step was taken towards a more ambitious goal in relation with emerging high-resolution imaging techniques, i.e.: to measure more exotic parameters named speckle lifetime or isoplanatic angle and to point out existing relationship with standard atmospheric parameters recorded daily all over the world by means of balloon-borne meteorological radio soundings.

During the subsequent years, the VLT site survey team in Chile dutifully gathered night after night an impressive data base on various mountains, which prompted ESO's governing bodies to take in December 1990 a decision of major consequences for ESO's future: the VLT observatory would be located in the Cerro Paranal area.

Figure 1: *The PARSCA team in front of the SCIDAR 80-cm diameter lens collector (from right to left: J. Beckers, S. Hernandez, E. Gizard, J. Vernin, J.F. Manigault, J. Navarrete, I. Gomez, M. Sarazin, A. Fuchs, B. Lopez, M. Azouit).*

The Campaign

Cerro Paranal emerged as an outstanding site with respect to cloudiness, water vapour content of the atmosphere and image quality, but little was known about the temporal behaviour of the wavefront. It was precisely to gain insights about how high above the site the thermal turbulence travels and how fast it moves that the PARSCA 92 campaign was organized, with a smaller number of participants than LASSCA because telescope time at Paranal is still a dream, but with innovating techniques using several tons of instrumentation*.

The Table below lists the recorded parameters and the measurement place. Due to the impressive levelling work still going on daily on the summit of Paranal, a nearby summit (nicknamed "NTT peak" for historical reasons) was used for the monitoring of image quality. The meteorological balloons were launched from the foot of Paranal to get them as close as possible to the summit during the initial phase of their ascent. As for the SCIDAR**, an 80-cm-diameter collector mounted in a sea-container (see picture), it stayed comfortably at the ESO base camp, being sensitive only to the atmospheric layers at more than 1 km over ground.

The campaign lasted 14 nights in March 1992 divided into two runs pro-

* External participants of the PARSCA Campaign: M. Azouit, A. Fuchs, J.F. Manigault, J. Vernin (Dept. d'Astrophysique, Univ. de Nice), S. Hernandez (Inst. de Astrofisica de Canarias), B. Lopez (Dept. A. Fresnel, Obs. de la Côte d'Azur), E. Gizard (Etablissement d'Etudes et de Recherches Météorologiques, Toulouse). The campaign was also partly attended by J. Beckers, ESO-VLT Programme Scientist.

** SCIDAR stands for SCIntillation Detection And Ranging.

Table 1: *List of atmospheric parameters measured each night during the PARSCA campaign*

Parameter	Instrument	Owner	Place
C_T^2 (1-30 km) and scintillation	SCIDAR	Astr. Nice	Base camp
Velocity of turbulent layers (1-30 km)	SCIDAR	Astr. Nice	Base camp
C_T^2 vertical profiles (0-30 km)	Balloon borne sensors	Astr. Nice	Paranal
Wind velocity/direction (0-30 km)	Radiosonde	CNRM Toulouse	Paranal
Temperature, humidity (0-30 km)	Radiosonde	CNRM Toulouse	Paranal
Seeing	Seeing Monitor	I.A. Canarias	NTT peak
Seeing	DIMM1	ESO	NTT peak
Scintillation	Scintillometer	ESO	NTT peak
Velocity of wavefront and Life time	DIMM 3 (modified)	ESO	NTT peak
C_T^2 (ground)	microthermal sensors	ESO	NTT peak
Wind, temperature, humidity	meteorological mast	ESO	NTT peak

viding the team with some days for rest and sightseeing. In addition to the gathering of an impressive amount of data (20 balloons were launched successfully), it was an opportunity to compare the new differential motion monitor of the Instituto de Astrofísica de las Canarias to the ESO DIMM. During this period also took place the first operational run of the new ESO Differential Motion and Coherence Monitor, a wonderful opportunity for calibrating this modified DIMM, able to deliver not only the seeing but also the temporal characteristics of the wavefront[6]. These parameters are awaited by the VLT planners in need of statistics for better designing the time sensitive VLT subsystems.

The more we improve our knowledge of the environmental conditions of the VLT Observatory, the more efficient is the operation of the telescope. Astro-Climatology is a tool to be used for telescope control as well as for flexible scheduling, i.e.: for optimally tuning the observation to the observing conditions. The PARSCA campaign brought a useful contribution to this task.

Acknowledgements

We wish to thank the members of the ESO administration in Garching, Santiago, La Silla and Paranal who solved, one after the other, all the logistical problems during the preparation of the campaign. We convey our special thanks to the Paranal team headed by P. de Jonge who accepted the additional workload and provided the PARSCA team with unexpected comfort and excellent working conditions at Paranal.

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New R.E.O.S.C. Polishing Facility for Giant Mirrors Inaugurated

On April 24, 1992, the French Minister for Research and Space, Professor Hubert Curien, inaugurated a unique, new optical facility of R.E.O.S.C., at Saint Pierre du Perray, near Paris. The delicate polishing of the giant mirrors for ESO's 16-metre equivalent Very Large Telescope (VLT) will take place here.

The festive act took place in the presence of about 300 invited guests, who were seated in the cavernous hall of the new building, just in front of the two polishing tables. They came from all over France and also from the neigbouring countries as representatives of European Science and Technology. The event also drew a lot of media attention and most of the French TV channels were represented. (The ESO video team obtained extensive material to document the VLT Tale.)

Following an introductory speech by the ESO Director General, Professor Harry van der Laan, in which he praised the very good cooperation between ESO and R.E.O.S.C., Dr. Daniel Enard from ESO spoke about the history of the VLT project, underlining the need to equip the world's largest telescope with optically perfect mirrors. M. Jean Espiard, Deputy General Manager of R.E.O.S.C. and formerly involved in the polishing of the main mirror for ESO's 3.6-m in the early 1970's, then presented the intricacies of the new factory, whose combination of size and incredible precision did not fail to impress the audience.

After a few further, short interventions by local officials, Professor Curien expressed a great satisfaction to see the new facility ready and he warmly congratulated R.E.O.S.C. and the planning staff to this most significant achievement. He mentioned the great optical traditions in France and that there are all chances that the VLT project will be achieved in the best possible way so as to become the world's first telescope at the end of the present decade. The Minister then unveiled a plaque commemorating the inauguration.

Figure 1: *Professor Hubert Curien (middle), French Minister for Technology and Space, at the inauguration of the R.E.O.S.C. facility on April 24, 1992. To his left, M. Bujon de l'Etang, Chairman and General Manager of SFIM) and to the right, M. Dominique de Ponteves, Chairman and General Manager of R.E.O.S.C.*

Polishing the World's Largest Optical Mirrors

It was in the summer of 1989, that ESO and R.E.O.S.C. signed a contract concerning the polishing of the four 8.2-metre mirror blanks for the ESO 16-metre equivalent VLT. This included the design and construction by R.E.O.S.C. of a completely new polishing facility, which would be able to handle this technically very demanding task.

In less than three years, the new 32-metre tall, 1100 m^2 R.E.O.S.C. optical laboratory was constructed and has also been equipped with the most modern, computer-controlled machines. One of these will perform the rough polishing. Another will give the four enormous mirrors their final form and ensure that the 50-m^2 surfaces will be exceedingly smooth, with residuals at the 5-nm level.

In order to carry out the corresponding tests, R.E.O.S.C. has built a very elaborate 32-metre high tower, just above this machine. The tower is a double structure which will protect the measuring device from any adverse influences from the outside and keep them at a constant temperature and humidity. All of this is necessary to realize the full potential of the VLT, so that it will be able to produce the sharpest possible images and detect and observe fainter and more distant celestial objects than any other telescope.

Transporting 8.2-Metre Mirrors from Mainz to Paris

The ZERODUR mirror blanks will be delivered by SCHOTT Glaswerke (Mainz, Germany). The first blank, which is now undergoing the final treatment there, will be picked up and transported by R.E.O.S.C. in May 1993; the three others will follow soon thereafter. The mirror blanks will be transported from Mainz to Paris by barge, down the river Rhine, along the Channel coast and then up the river Seine to the town of Evry, near the R.E.O.S.C. VLT facility.

So if you happen to be in Paris in the late spring of 1993 and you see a heavily loaded barge carrying a 10×10 m^2 rather flat box, slowly passing the Eifel tower, you will now know what is inside!

The Editor

Speech by the ESO Director General, Prof. H. van der Laan:

Monsieur le Ministre, Monsieur Bujon de l'Etang, Monsieur de Ponteves, Monsieur Espiard, Mesdames et Messieurs,

L'Observatoire Européen Austral (l'ESO) est une organisation créée pour rendre l'astronomie européenne plus intéressante, plus ambitieuse et plus compétitive. Maintenant dans sa trentième année, l'ESO a amplement démontré que la persévérance rapporte: il n'y a aucun doute que les premières années furent difficiles, les progrès trop lents à venir, et la qualité et la quantité de temps de télescope, par million de francs dépensé, décevantes. L'histoire de cette lutte est relatée dans les livres écrits par les leaders de la permière génération, les Professeurs Fehrenbach et Blaauw. Mais les lecteurs du MESSENGER, le magazine trimestriel de l'ESO, savent bien combien l'allure et la vitesse ont changé, dans quelle mesure, on pourrait dire dramatique, optique, électronique, opto-mécanique et systèmes de contrôle, détecteurs et logiciels ont été intégrés afin de réaliser des performances encore inconnues il y a une décennie. Le Télescope à Nouvelle Technologie (le NTT) est la concrétisation de ce progrès, mais le télescope de trois mètre soixante partage une bonne part de ces innovations. Son grand miroir mais aussi ses miroirs secondaires et coudé furent polis par REOSC sous la direction de Monsieur Espiard, avec assez d'habileté artisanale et de précision pour maintenir le télescope à la tête du progrès pour des décennies.

L'ESO est au service de la communauté de recherche et pour accomplir ce devoir, l'organisation dépend de l'ingéniosité et de la persévérance innovative de l'industrie. REOSC, et avec elle une poignée d'entreprises européennes, a décisivement participé aux progrès de l'ESO et a toujours répondu a ses aspirations. REOSC eut le courage d'accepter que ces attentes fussent changées en obligations contractuelles.

Aujourd'hui nous célébrons une pierre milliaire dans l'histoire commune de REOSC et de l'ESO, une borne milliaire aussi dans l'histoire du VLT, le grand télescope de l'Europe des prochains cinquante ans. Au nom de l'ESO, de notre personnel, de notre communauté d'utilisateurs je remercie l'équipe de REOSC pour la collaboration splendide et je vous félicite de cette installation essentielle pour atteindre notre but commun.

L'ESO et REOSC partagent trois lettres de nos noms acronymes. Mais REOSC en a deux de plus: le 'C' ce qui, je crois, représente la Créativité et le 'R' sans aucun doute désigne la Résolution. Que ces dénominations continuent d'être vos caractéristiques.

Je vous remercie de votre attention.

Figure 2: *Professor Charles Fehrenbach (right), former Director of the Haute-Provence Observatory and Chairman of the ESO Instrumentation Committee, with Dr. Daniel Enard of ESO, in front of one of the large polishing tables.*

Distant Radio Galaxies

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1. Introduction

We are at present carrying out an ESO Key Programme to find and study distant radio galaxies using a new technique. Here we give a "mid-term" progress report. The Key Programme is based on a method that we developed for optimizing the chances of finding distant radio galaxies. It is based on a correlation that exists between radio spectral index and redshift. Radio sources with the steepest spectra tend to be more luminous and at larger distances than sources having normal spectra.

The direct objectives of our key programme are twofold. First we wish to increase the sample of distant galaxies and investigate the statistics of the population. Secondly, we are studying the detailed properties of the early-epoch radio galaxies in an attempt to understand how they formed and evolved.

2. Background

In the late forties, Cygnus A, the second brightest radio source in the sky, was found to be associated with a faint galaxy having a redshift 0.057. This remarkable discovery led to the realization that radio sources are unique cosmological probes. There are three main reasons why radio galaxies are so important for studying the early Universe. First, their radio luminosities are sufficiently large to enable them to be easily detected out to large redshifts. Secondly, most of them also emit intense emission lines which enable their redshifts to be easily measured. Thirdly, unlike quasars, radio galaxies are spatially extended in the optical and infrared.

During the last decade CCDs have revolutionized studies of distant radio galaxies, enabling much fainter galaxies to be imaged and their redshifts to be measured spectroscopically. From the theoretical standpoint, the search for and study of galaxies having redshifts in excess of 2 or 3 became increasingly important as theoretical arguments based on the canonical "cold dark matter" cosmologies indicated that it was during or after the epochs corresponding to these redshifts that the majority of galaxies were formed.

Until a few years ago, it was thought that although radio sources were used to detect distant galaxies, the radio emission could be "forgotten" in subsequent consideration of their optical properties. However, CCD pictures of distant galaxies showed surprising correspondence between the optical and radio structures. The optical and to a lesser extent the infrared emission were found to be preferentially aligned along the radio axes. The optical/radio alignment is present both for the optical emission lines and the continuum.

The fraction of objects which possess ionized gas halos increases dramatically at redshifts greater than about 0.1. The alignment of the halos with the radio emission can be readily explained by interaction of the jets with the interstellar and intergalactic gas. The more vigorous interaction observed at large redshifts implies that distant radio galaxies may have more gas than nearby ones. The ionized gas halos could then be associated with the collapse of an embryo galaxy during its formation.

The second effect to be observed was more surprising. Not only was the line emission (ionized gas) observed to be aligned along the radio axis, but so also was the optical and infrared *continuum* radiation. The continuum alignment seems to set in at a redshift of about 0.6 and about 80 % of radio galaxies having redshifts in excess of 1 have radio and optical continuum structures which are approximately aligned.

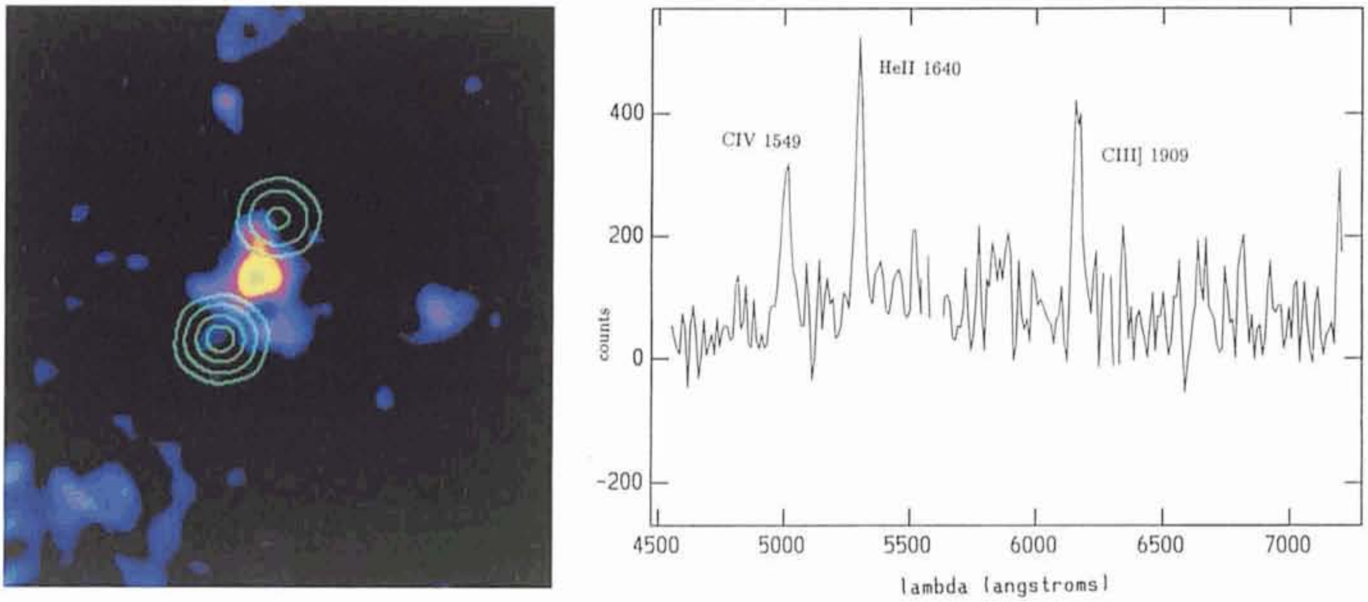


Figure 1: *A z = 2.2 galaxy associated with a Texas radio source. Left is an R-band image (60-minute exposure with the 2.2-m ESO/MPI telescope). The image has a limiting magnitude of ~ 24. The superimposed radio contours are from "snapshot" observations taken with the VLA at 20 cm. The two lobes are separated by 5". Right shows the corresponding optical spectrum (60-minute exposure with EFOSC2 on the NTT).*

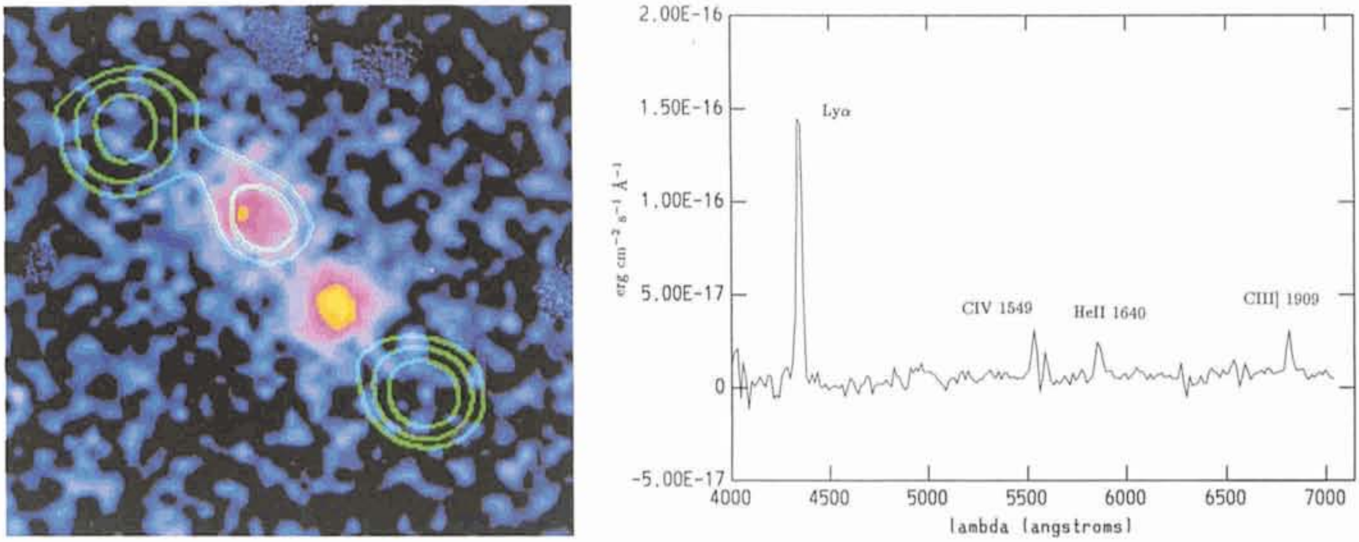


Figure 2: *A z = 2.5 galaxy associated with a Texas radio source. Left is an R-band image (45-minute exposure with 2.2-m ESO/MPI telescope). The image has a limiting magnitude of ~ 24. The superimposed radio contours are from "snapshot" observations taken with the VLA at 20 cm. The two lobes are separated by 12". Note the double optical morphology (see text). Right shows the corresponding optical spectrum (a 45-minute exposure with EFOSC on the 3.6-m telescope).*

Two viable explanations for the optical continuum/radio alignment have been proposed. One possibility is that interaction of the radio source with the intergalactic medium results in the production of a sufficient number of stars to produce the aligned component of the optical continuum emission. An alternative to the starburst picture was prompted by the measurement of appreciable optical polarization in extranuclear emission from the bright aligned radio galaxy 3C 368 by Sperello Alighieri, Bob Fosbury, Clive Tadhunter and Peter Quinn working with EFOSC on the ESO 3.6-m telescope. This led to the suggestion that the aligned optical continuum light that we see from distant radio galaxies is scattered emission from a quasar embedded in the nucleus. Because the quasar shines in a narrow cone along the radio axis, we are unable to see it directly. However, electrons or dust along the radio source see the beam of quasar light and scatter it.

Neither the starburst nor the scattering models by themselves are entirely satisfactory. The presence of polarization means that some scattering must occur, but it cannot be the whole story. In some of the distant galaxies, structures are observed to be aligned with the radio emission, not only at optical wavelengths, but also in the infrared. Using a scattering model it is difficult to produce enough emission to account for the observed aligned luminosities. A composite picture of distant radio galaxies which includes both bursts of star formation and scattering along the radio sources seems most likely. Studies of additional high-redshift galaxies are clearly warranted.

3. Finding Distant Galaxies

Barely five years ago, the most distant galaxy known was 3C326.1 with a redshift of 1.8. By concentrating on identifying "ultrasteep spectrum" radio sources, we have since discovered about 25 galaxies having redshift larger than 2, most of these during the ESO Key Programme. At the time of writing, the three galaxies with the largest known redshifts were all found using our ultrasteep spectrum technique.

Finding the high-redshift galaxies has involved a long series of systematic steps at radio and optical wavelengths. After each stage the number of candidates was whittled down. We first made a preliminary selection of several samples of radio sources known to have definite or suspected ultra-steep radio spectra from the Parkes, Molonglo and Texas surveys. Using these initial selection criteria, 650 objects were selected from more than 50,000 sources inspected.

The next stage was to carry out preliminary radio observations with the VLA, and Molonglo Synthesis Telescope (MOST) to find out which of the suspected sources definitely have ultra-steep spectra and to provide radio structural and positional information which can be used for their optical identifications. To this end we made snapshot observations of 550 sources. Using the accurate radio positions, we then sought optical counterparts of the radio sources on Sky Survey plates using the GASP system at the Space Telescope Science Institute in Baltimore. About 80% of the sources in our sample were unidentified.

We then began our ESO observations by making CCD images of ultrasteep spectrum sources that were unidentified on the Sky Survey. With exposure times of typically 3 × 15 minutes through an R-filter on the 2.2-m telescope, we reach limiting magnitudes of about 24. So far we have imaged 170 of the 300 candidates that remained after the preliminary stages of the project had been completed. In order to search for optical identifications, the CCD frames need to be calibrated astrometrically using stars that are present both on the CCD image and on the Sky Survey. All the CCD images have been calibrated and the radio maps have been superimposed. Two examples of our radio/optical overlays are shown in Figures 1 and 2. We selected faint fuzzy optical counterparts on the CCD frames as candidates for optical spectroscopy.

There is a dramatic increase in the space density of quasars between $1.5 > z > 2.8$, the "quasar epoch". Although the detailed behaviour is still uncertain, it appears that the radio galaxy statistics are consistent with a roughly similar behaviour. For objects which are located in the quasar epoch, Lyman α will be observed blueward of 4600 Å. Because in a characteristic spectrum of a radio galaxy Ly α is a factor of 5–10 more luminous than any other observable line, maximum sensitivity in the blue is crucial for measuring the redshifts.

Until recently, there was no CCD on La Silla capable of doing spectroscopy with high quantum efficiency in the blue and low readout noise. The availability of the new Tektronix chip with EFOSC on the 3.6-m telescope has remedied this situation. We used this chip for

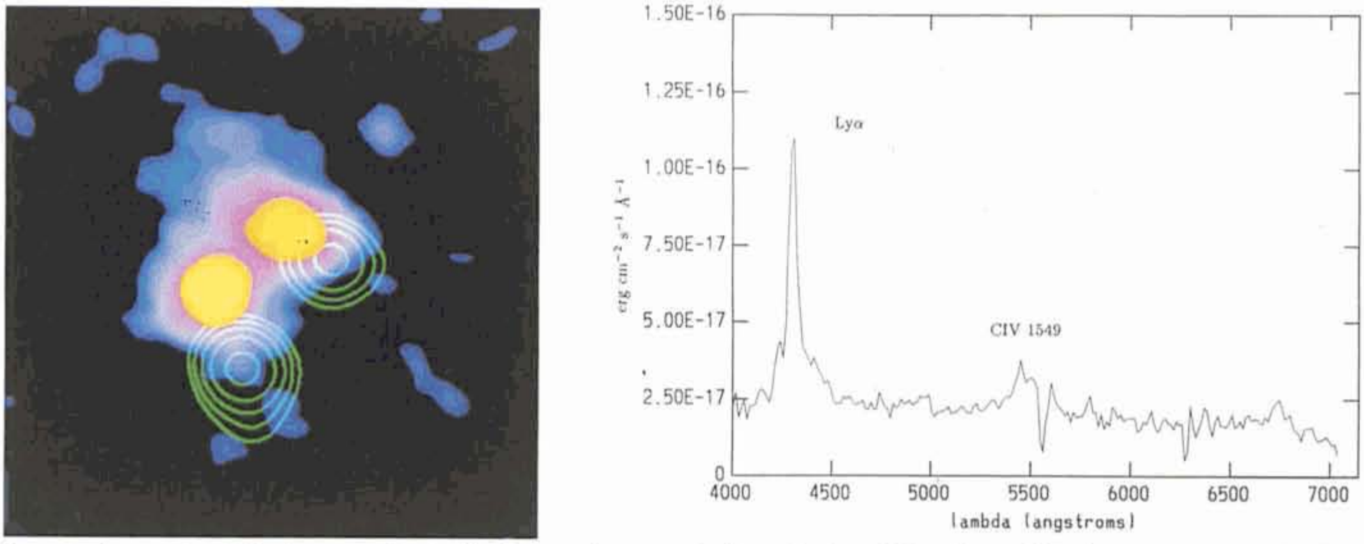


Figure 3: *A second z = 2.5 galaxy associated with a Texas radio source. Left is a 16-minute R-band image (10-minute exposure with EMMI on the NTT). The image has a limiting magnitude of ~ 24. The superimposed radio contours are from "snapshot" observations taken with the VLA at 20 cm. The two lobes are separated by 4". Note the double optical morphology (see text). Right shows the corresponding optical spectrum (60-minute exposure with EFOSC on the 3.6-m telescope).*

the first time on our last observing run and it resulted in a significantly improved detection rate. Taking all the data obtained so far, we have detected emission lines in 30 of the 85 galaxies that we observed spectroscopically. We have determined 30 redshifts of which 23 have z > 1.5 (e.g. see enclosed figures).

The statistics of the photometry and spectroscopy are being analysed together with radio source counts and spectral index distributions and size distributions to place constraints on the evolution of space density of radio galaxies and to compare the redshift dependence of the luminosity function of radio galaxies with relevant data for quasars. In practice such an analysis is complicated and requires considerable care. Well-defined criteria are being developed to allow the identification percentages to be analysed quantitatively, preparatory to constraining the evolution of the luminosity function. Our spectroscopy was done in several separate sessions with different sensitivities and different colour responses. For each of these it is necessary to determine the limiting redshift out to which a standard radio galaxy could have been detected. Account has also to be taken of the radio spectral selection criteria used. A rigorous discussion of the relevant constraints will be undertaken by H. Röttgering in his Ph.D. thesis which is expected to be completed late in 1992.

4. Follow-Up Observations

At this stage, we are only about half way through the nominal observing time allocated for the Key Programme. Inevitably, most of the time until now has been devoted to finding new distant radio galaxies. Detecting distant radio galaxies is a prelude to studying their properties. The quasar era at z ~ 2 occurred only about 2 billion years after the Big Bang. Galaxies at larger redshifts are likely to be close to the epoch of their formation. Because they are spatially extended, radio galaxies pro-

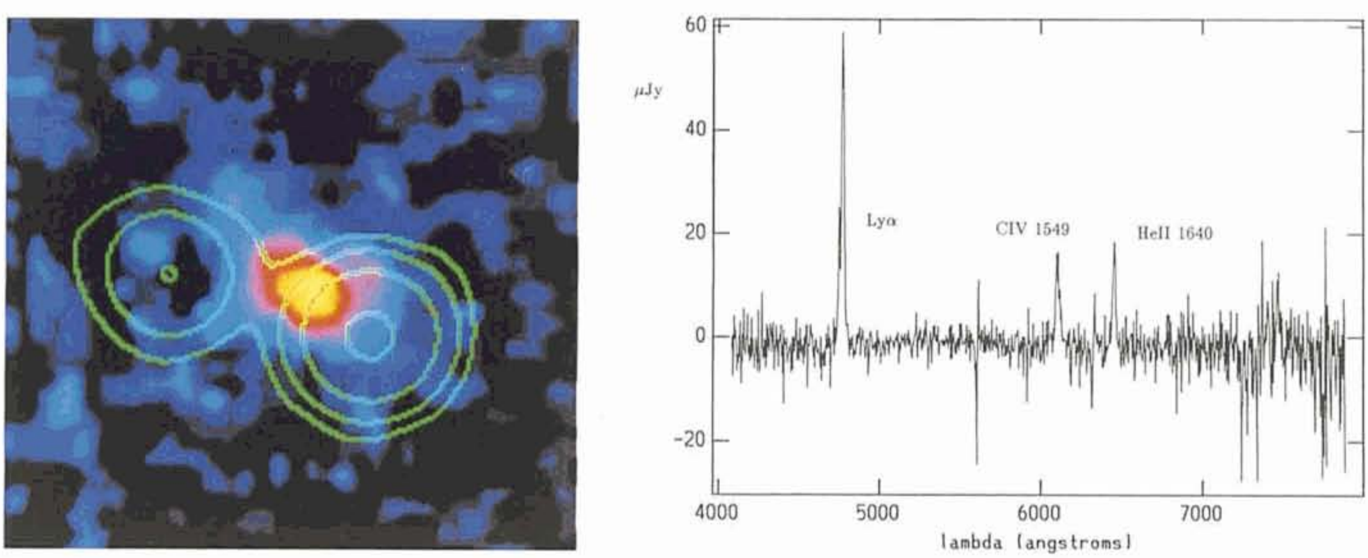


Figure 4: *A z = 2.9 galaxy associated with a Texas radio source. Left is an R-band image (16-minute exposure with EFOSC2 on the NTT telescope). The image has a limiting magnitude of ~ 24. The superimposed radio contours are from "snapshot" observations taken with the VLA at 20 cm. The radio extension is 4". Right shows the corresponding optical spectrum (120-minute exposure with EFOSC2 on the NTT).*

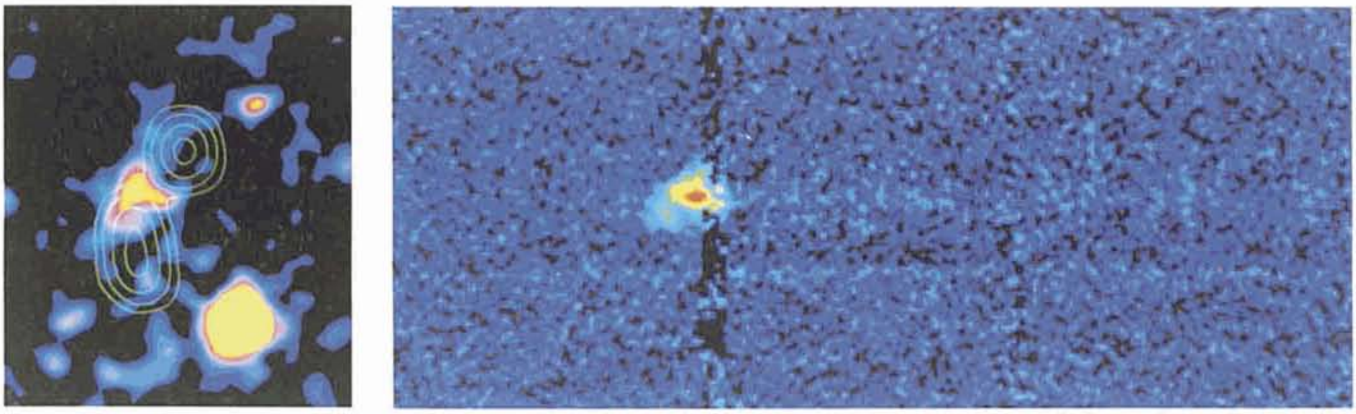


Figure 5: *A galaxy associated with a Texas radio source having a probable redshift of 3.6. Left is an R-band image (45-minute exposure with the 2.2-m ESO/MPI telescope). The image has a limiting magnitude of ~ 24. The superimposed radio contours are from "snapshot" observations taken with the VLA at 20 cm. The two lobes are separated by 7". Right shows the corresponding sky-subtracted 2-dimensional spectrogram (120-minute exposure with EMMI on the NTT). The horizontal axis (wavelength) extend from 5270–6260 Å and the vertical axis is in the spatial direction along the radio axis. One very bright line is observed with a spatial extent of about 8". The continuum falls off sharply bluewards of the line. The only tenable line identification is Lyα at $z = 3.6$.*

vide unique diagnostics for studying this important stage in history. Since in most cases, the associated emission lines are both bright and extended, they are excellent objects for follow-up spectroscopy as well as narrow-band and broad-band imaging.

Two interesting objects for which we have already done a limited amount of follow-up are shown in Figures 2 and 3. In both cases the following properties are apparent:

(i) A pair of apparently interacting optical objects are aligned along the radio axes.

(ii) Each member of the pair is anomalously bright in R. (Integrated R-magnitudes are 19.7 and 20.8 respectively compared with a typical value of 23 for other radio galaxies at the same redshift ($2 < z < 3$).

(iii) Bright Lyα extends for > 5" over each system.

From these properties we were led to consider the possibility that both objects may be primeval galaxy mergers. However, a study of the extent of the line emission and the colour distributions now leads us to believe that one member of each pair may be a foreground object.

To investigate the probability of chance coincidences in objects of this kind, we are analysing the number vs. magnitude statistics in each of our CCD frames. This study will also provide an important input into discussions of the identification statistics and luminosity function evolution.

We are planning a variety of additional follow-up observations of our highest redshift galaxies. Detailed mapping of the (optical and infrared) spectral energy distributions and analysis of their variations across the galaxies should provide constraints on the optical/radio alignment effect. Models of stellar populations are being refined by Rocca and Guideroni of the Institut d'Astrophysique in Paris for comparison with the spectral energy distributions. The optical data will be complemented by more detailed radio observations with radio arrays, including the Australia Telescope and European and global VLBI networks. A recent discovery by Uson of HI absorption in the radio spectrum of a similar radio galaxy with $z = 3.4$ offers exciting possibilities for using some of our objects for probing neutral gas in the early Universe.

Also, study of the morphologies and kinematics of the ionized gas and the relationship of the line emission to the continuum emission should elucidate the processes responsible for ionizing the gas. The ionized gas halos often extend for more than 100 kpc. The observed nuclear fluxes are insufficient to produce the large emission-line luminosities by photoionization, lending support to the models involving anisotropic photoionization and scattering.

The Key Programme is providing us with a unique dataset of radio galaxies at distances that would have been thought impossible until a few years ago. Studies of these objects from now until deep into the VLT era should provide important information about the early universe.

European Planetarians Meet at ESO Headquarters

On May 10 and 11, 1992, about 75 Planetarians, representing planetaria from most European countries, gathered at ESO Headquarters in Garching. It was the third meeting of this international group, following earlier ones in Strasbourg (1986) and in Paris (1989). The local arrangements were taken care of by the ESO Information Service, while the scientific programme was organized by Professor Agnes Acker of the Astronomical Observatory at the University in Strasbourg, herself responsible for the planetarium in that city.

The meeting was preceded by a study visit to the Deutsches Museum in München, where the participants were received by the museum staff responsible for the new astronomy exhibition, just opened there (cf. page 21). Under the expert guidance of Drs. Teichmann, Hartl and Wolfschmidt, who first conveyed the new ideas behind the 1000 m^2 exhibition, the Planetarians had the opportunity to thoroughly study the numerous displays. Later in the day, they were informed about the new, major planetarium project which will be ready in Munich in 1993.

The actual meeting began at ESO in the late Sunday afternoon with a warm welcome by the Director General, Professor Harry van der Laan, who emphasized the importance of close connections between the planetaria and the scientific institutions. The scientists produce the new discoveries which are then conveyed to the public by the professional planetarians. Together, they work to explain the science which is an indispensible part of our general culture.

This intervention was followed by a demonstration of some of the latest ESO video films and other educational and publicity products from the ESO Information Service. One of the ESO astronomers spoke about the VLT project and some of the research projects which will be undertaken with it, beginning in 1996 when the first 8.2-metre VLT unit telescope will be ready at Paranal. Thereafter, the participants had the opportunity to visit various areas of the ESO Headquarters, including the Remote Control facility, the image processing room and the photographic laboratories. At each place, ESO staff explained the techniques. The possibility of observing from Germany with a telescope in Chile, 12,000 km away, was particularly impressive to many of the participants.

Figure 1: *The ESO Director General, Professor Harry van der Laan, welcomes the European Planetarians to ESO.*

Figure 2: *Geert Dobbels, Remote Telescope Operator at ESO, explains the Remote Control Facility in Garching, from where observations are made with the New Technology Telescope at La Silla.*

Figure 3: *Claus Madsen from the ESO Information Service demonstrates some of the photographic techniques employed in the sky atlas laboratory at the ESO Headquarters.*

The evening ended with a festive conference dinner in a very Bavarian environment.

The next day was fully devoted to the presentation of new projects and techniques and the individual planetaria, and several demonstrations of new equipment were made.

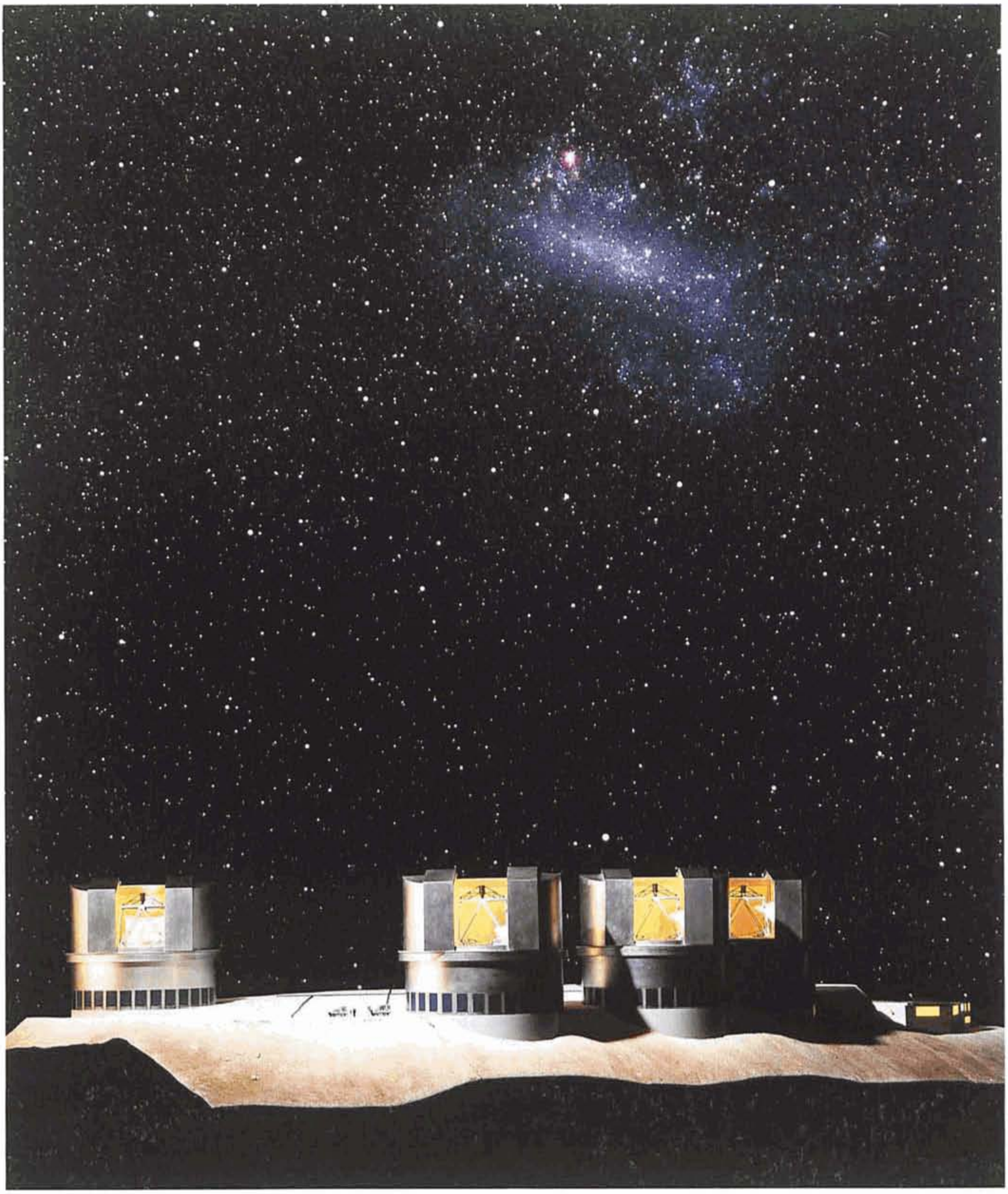
ESO was pleased to be host to this meeting and to inform this distinguished audience about the scientific and technical work taking place at this organization. At the same time, many Planetarians in Europe learned more about the various materials, available from ESO and which may be useful for their work. The meeting was a good demonstration of how the common cause may be furthered by mutual support and it certainly contributed to bringing the originators and the disseminators of astronomical information closer to each other.

The Editor

The VLT Tale

ESO announces its latest video film: THE VLT TALE. It has been produced by the ESO Video Team and describes the background and the first fifteen years (!) of the ESO 16-metre Very Large Telescope project. Beginning with the very first, vague ideas in 1977, it follows the many-sided developments that have led to the present, hectic construction phase. The VLT is placed in its historical context and some of its many high-tech features are explained.

THE VLT TALE is available from the ESO Information Service (address on the last page), in VHS and S-VHS format; the duration is 29:20 min. The price is 70.– DM and prepayment must accompany each order. Please be sure to indicate the desired format.



A Giant VLT Model for Seville

Just before the new VLT model left for EXPO'92 in Seville, ESO photographer Hans-Hermann Heyer made this picture of it in the ESO Council Room. This is the only place at the ESO Headquarters which is big enough to accommodate the vast dimensions of the 1:35 model: 3 × 4 × 1 metres.

The model represents the VLT configuration as it was in early 1992. In the meantime, some minor changes have occurred (which will be corrected in the model when it comes back to the ESO Headquarters in late 1992. In particular, since an extra 5 metre will be removed from the top of the Paranal mountain, i.e. altogether 28 metres, the VLT platform will become even larger and the individual domes will be farther away from the edge of this platform.

The VLT model was duly transported to Seville and is now on display in the Pavillion of the Future. Standing in front of it, the visitors will find a small table with eight buttons. Pushing one of them they will experience one of four short viedeo films produced by the ESO Video team in English or Spanish and will see some interesting examples of the different types of research that can be done with the VLT.

ESO Exhibitions in Chile – a Tremendous Success

P. BOUCHET, A. CABILLIC, ESO, La Silla
C. MADSEN, ESO, Garching

1. Introduction

After having travelled over South America, with stop-overs in Rio de Janeiro and Buenos Aires (during the IAU General Assembly), the ESO exhibition was set-up in Santiago, at "Universidad de Chile", where it attracted more than 18,000 visitors during last December. Concurrently and in the same premises, conferences were given by ESO astronomers Olivier Hainaut and Andrea Moneti, and by Chilean astronomers from that university (Maria Teresa Ruiz, José Maza, Leopoldo Infante) and "Universidad Católica" (Hernan Quintana). The impact of such an undertaking was a surprise for all of us. Although we were concerned that the official "Salón de Honor" of the university would be too large for the expected audience, it could hardly contain the numerous and enthusiastic public who rushed upon this opportunity to learn more about astronomy in general, and ESO (and its VLT project) in particular. A great interest from the public, a great fun for us and the speakers: a really big success.

As a consequence, ESO has been requested by several universities and organizations to set up the exhibition in various other places throughout Chile, and ESO is now considering how best to meet these demands. Next firm rendezvous has been taken in Antofagasta, a very important place for ESO's future.

Besides these larger exhibitions, ESO participated in the fairs of Peñuelas, "FINOR" (Feria Internacional del Norte) and of Ovalle, and these were great opportunities to meet the public of the 4th Region, which hosts La Silla.

2. The Peñuelas Exhibition

Peñuelas was originally a fishermen village, along the beach between La Serena and Coquimbo. Some fishermen are still active there but no longer the heart of the village, transformed into one of the attractive beach resorts in Chile. Every summer, during the touristic peak, a "FINOR" takes place, a good opportunity to show to people coming from all over Chile and neighbouring countries, what is happening in the North. ESO could not be absent from such an event.

Together with a selected part of the standard exhibition, a 11" Celestron telescope was installed on the site. Indeed, our stand and our telescope turned out to be one of the principal attractions of the fair. The interest of the public was demonstrated by the crowd of people visiting our stand, the numerous questions asked (some very interesting), and the patience of those queueing up to get the chance to glance at Jupiter or the Moon. The enthusiasm of the public rewarded well the efforts ESO put into the event. Also we had a chance to clear the confusion many visitors made between ESO and CTIO. After a few days of exhibition, several broadcasted interviews and a 15-minute documentary presented during the local TV news, this confusion did not occur so often.

Our stand was visited by the Ministers of Agriculture, Mr. Juan Agustin Figueroa, of Mining and Energy, Mr. Juan Hamilton, all Deputies and Senators for the IVth region, the provincial Governor, the Mayors of La Serena and Coquimbo who showed a genuine interest in learning more about ESO. Mr. Renán Fuentealba, the "Intendente" (highest authority) for the IVth region came several times to our stand, and twice at night with his family to look through our telescope. Most of the ESO local and international staff living in the La Serena area visited us, showing great satisfaction at the initiative taken by the Organization. What may be most important is that a great number of professors and students came and asked all kind of information. The permanence of an astronomer during the fair was therefore a requirement.

A total of about 80,000 people visited the fair, of which more than two thirds actually visited our stand. As for the telescope, we had only one cloudy night, and people queued up from 8:30 p.m. till 2:00 a.m. (and even later during weekends): with a typical *observing time* of 15 seconds each, about 13,000 people "observed" during the whole fair! Our stand was the last to close at night and on Saturdays and Sundays we had to require the help of the "Carabineros" to control the queue, and close the observing runs by 3 a.m.!

As a recognition for this success and our efforts, ESO was one of the 3 stands (among 100) awarded a special distinction during the closing act of the fair. Although this prize is highly symbolic, it clearly shows the impact of the ESO presentation at this event.

Following this great success, ESO

The official opening of the fair. The Minister of Agriculture, Mr. J. Figueroa, with ESO staff P. Bouchet, A. Cabillic and J. Peralta.

General view of the ESO stand with public.

P. Bouchet and J. Peralta (who usually attend the ESO office at the bus terminal station in La Serena) with the "queen" of the fair, Miss Terry-Ann Maxwell.

R. Vega and P. Bouchet with the "1st vice-queen" of the fair at the ESO Celestron telescope.

was requested by the organizers of *Expovalle* to participate in that fair, too.

3. The "Expovalle" Exhibition

Ovalle, a city of 100,000 inhabitants and the capital of the *Limari* province, is located 80 kilometres inland from La Serena. Since 1980, the *Limari* valley has become the regional leader in agriculture. It produces 70 % of the grapes for *Pisco*, it contains 61 % of the regional surface devoted to fruitgrowing, and concentrates 95 % of the region's hydraulic resources (10^9 m^3). Since 1990, a fair called *Expovalle* is competing with the FINOR for the status of the most important agricultural, mining and industrial demonstration of the North of Chile. The 1992 Expovalle took place in early May with a declared objective to gather more than 100 exhibitors and attract 60,000 people. To reach that goal, big shows of a national level were organized: th 3rd Chilean *Huasos* games competition, bailing out demonstrations with the national champions, stunt performances by the national team of the Chilean Air Force, outstanding national singers, etc...

Four months after participating in the FINOR, it was indeed useful for ESO to go to Ovalle. While the more commercial FINOR attracted mostly tourists and city people, the Expovalle reached a different, grassroots public, equally, if not even more, curious about astronomy and ESO.

Once again, our stand with our telescope was one of the principal attractions of the fair (if not *The* one). Also, an important dissemination effort was developed during the fair: 3 conferences (one of which devoted to teach general astrophysics to students) were organized on the location of the fair; two one-hour broadcastings took place every day, during which the audience could phone and ask questions: during one such broadcast 75 people called. This showed the very large interest, not only for astronomy in general (basic knowledge, its goals, its usefulness), but also for ESO and its future plans in Chile (the VLT of course!). Several regional personalities and a great number of professors and students visited our stand.

About 30,000 people in total visited our stand in Ovalle, of which about 7500 got "observing time". As in Peñuelas, although the stands closed at 1 a.m. we could never cut the queue before at least one hour later.

4. Dedication of ESO Staff

The success of the ESO exhibition during these two regional events could never have been so great without the

The Head of the La Silla Administration department, A. Cabillic, with officials during the opening ceremony. At the centre of the picture, the Mayor of Ovalle, Mr. E. Darrigrande.

ESO infrared operator R. Vega explaining the VLT project to a group of students.

A view of the queue to glance at Jupiter with the ESO 11-inch Celestron.

A view of the ESO 11-inch Celestron telescope. Also the youngest were much interested in seeing Jupiter!

collective and enthusiastic help of many ESO staff members in the preparation of the exhibit and in the most friendly attention to the public. In particular, we highly appreciated the competence of Messrs. Rolando Vega and Eduardo Matamoros during the setting-up of the exhibit and the telescope as well as their extraordinary patience in attending the public during observing time and the help of Mr. Jorge Peralta (attending our stand). We would also like to acknowledge the valuable assistance at La Silla of Messrs. Jaime Alonso and Aldo Pizarro who helped with the electronics of the telescope, and Armando Bruna and Victor Echeverria who built a new mount for it.

5. Conclusion

Among the large public who attended our stands and telescope, a few characters gave us some occasions to smile and we would like to share those with the readers: an old couple, after a glance at our sign (La Silla), made an immediate link with the chairs (*sillas* in Spanish) in front of our video screen, and decided to buy them on the spot (it was not easy to convince them they were not for sale!); this other man was very disappointed to realize that even with a telescope one could not watch the sun at night; that lady blamed us for reproducing in our NTT Saturn picture (the one with the white spot) the colours she had painted on some plates (after being convinced of our good faith, she left with the assurance that heavens had contacted her while she was painting!)

Other reactions were more touching: the old lady crying and kissing us for having given her the possibility to see a planet before she dies; the many people kneeling and crossing themselves to thank God for the beauty of the universe; some who just could not believe that they were actually seeing a "real" planet. Finally, one anecdote deserves special mention: with the telescope pointing at Jupiter, a drawing was made of the planet and its 4 largest "moons", with a note saying that Jupiter has 16 "moons" in total. Several women were standing near the telescope, very interested and enthusiastic about what other people were seeing, but absolutely refused to have a look at it themselves. Puzzled by such attitude we investigated the case. So we learnt that an old folkloric belief says that if a pregnant woman looked at the moon, her baby would have birthmarks. Now just imagine a poor creature whose Mom looked at 16 moons! We can credit ESO for the destruction of this belief in a number of minds.

As a scientific organization, ESO has a role to play towards the public at large (and in Chile, in particular). To spread the knowledge about some of the mysteries of the Universe is a moral obligation every astronomer should feel (not only to justify his existence!). However, not only astronomers, but also many people working at ESO, are proud of what ESO has built in Chile, of belonging to this Organization, and they like to make our beautiful observatory known.

For that reason, it has been really satisfactory to verify, first in Peñuelas, and then in Ovalle, that the response from the public makes up for the exhausting work such efforts implied. For sure, La Silla is now well known in the IVth region of Chile and – what is maybe more important – a window towards astronomy has been opened to a population eager to understand what it is all about. For a long time, ESO was not known in Chile as it should have been. Things are changing, for the best benefit of the public at large, for the ESO employees, and hence... for Astronomy.

The Youngest Visitors Yet

The call came early in the morning from Mrs. Keller. She was at the European School in Munich, she said, and she would like to hear whether it would be possible to visit ESO with a class. It would be so interesting for the children to learn about astronomy and also to see their parents at work.

Now, some *Messenger* readers may not know that the European School in Munich is one of a dozen "European" schools, established in major European cities, where there are "European" institutions. In the case of Munich, the school there was set up and operates in close collaboration with the European Patent Office. Children of ESO staff have access for some years under an arrangement with this organization.

It is always a particular pleasure to explain astronomy to young people and with the special relationship between this school and ESO in mind, I had little doubt that such a visit must somehow be arranged, and that a hole in the otherwise rather tight schedule of visits to the ESO Headquarters should be found.

The children had already studied the planets, Mrs. Keller said, and they were very eager to learn more. Perhaps we could show some slides? If it would not

Photograph by H.-H. Heyer

be too much trouble to receive 20 children of age 4–6 from the Kindergarten in the German language section?

A challenge! And why not? If I said no, a future Copernicus might decide to let another science benefit from his/her abilities . . . So of course I said yes, while wondering how to entertain such a group and what the other ESO staff would say, when some of their youngsters suddenly turned up at their place of work.

The photo, taken on the balcony outside the ESO cafeteria after the tour, shows how nice the children were. Not only did they know a lot about Mars and Jupiter, they also asked questions which were way beyond what you would expect from persons of that age. It was a real pleasure, especially to watch from a distance when Miguel Albrecht of ESO (whose daughter was in the group) showed a beautiful galaxy on the computer screen of MIDAS and to hear the gasps when he made it change colours.

After a sandwich lunch, the visit finished with a look through a small telescope at the cars in a distant car park. Patiently waiting for their turn to approach the instrument, and extensively discussing what they saw, I understood that the visit had paid off. Not only was it obviously fun; I am sure that the children came away with a good impression.

Two days later, the telephone rang and a teacher from the Munich European School called to ask if a Spanish-speaking class could perhaps visit ESO . . . But this time I answered truthfully that the visit calendar is booked out long in advance and we are rather few at ESO – maybe we could discuss such a visit in a couple of months' time?

R. WEST, ESO

A Most Impressive Astronomy Exhibition

Next time you come to Munich, don't miss the opportunity to visit an outstanding new astronomy exhibition!

In early May 1992, the world's largest technical museum, the Deutsches Museum which is located in the middle of Munich on an island in river Isar, inaugurated what is most probably the largest and most comprehensive astronomy exhibition in the world, and in any case the most up-to-date.

After more than five years of planning, involving a large team of museum specialists and scientists, the new, 1000 m^2 exhibition opened its doors to the public and was quickly and completely overrun by interested visitors. This event was accompanied by a "Science Press Conference" on May 6, featuring 12 brief talks by well-known scientists and covering the grand lines of virtually all of modern astronomy. It was attended by about 200 media representatives from Germany and several other European countries and was widely reported in the media.

The exhibition was conceived and realized by a team headed by Dr. Jürgen Teichmann of Deutsches Museum and supported by scientists from many research institutes in Germany, including ESO. The former Director of the Max-Planck-Institute for Astrophysics in Garching, Professor Rudolf Kippenhahn, played a decivise, coordinating role.

The basic idea has been to show what modern astronomy really is and how it is done, while also demonstrating the long development that has transformed the oldest of sciences into one of the most modern and exciting ones. The Deutsches Museum is in a unique position to do so, thanks to its very extensive collections of historically important instruments. In this context, ESO was very pleased to make available its 1-metre active optics mirror and support system with which this revolutionary optical invention was first demonstrated. Only a few years old, this equipment is now on display in the same area as the earliest astronomical telescopes, representing yet another decisive step forward in astronomical technology. The principle of adaptive optics is of course also explained here. There are lots of radio astronomy, a section of a of real 15-metre submillimetre antenna, the latest X-ray results from ROSAT, gravitational lenses, missing mass, Big Bang revisited, the end of the Universe, image processing stations, etc.

The exhibition is grouped in a somewhat unusual way. Believing that the visitors come to have their curiosity satisfied, the "answers" to many "questions" are given, by extensive use of advanced didactical means. The public will not only see beautiful pictures and the sky and its objects; there is also a substantial number of interactive displays which serve to involve and attract even those who have no particular previous relations to our science. There are several very realistic experiments, e.g. aberration, photoelectric lightcurves of an eclipsing binary, the origin of spectral lines, etc.

Visit the exhibition, when you come to Munich – you will not regret it!

R. WEST, ESO

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Astronomical Observations in 2001

D. ALLOIN and T. LE BERTRE, Observatoire de Paris, Meudon, France

A forum organized by INSU with the support of ESO was held in Paris on March 20, 1992. The motivation of this one-day meeting was to resume the discussions within the astronomical community about the future operating modes of telescopes in the VLT era. We enjoyed the visit of an important delegation from ESO Headquarters.

P. Shaver gave a review of the study made a few years ago by the "VLT Operation Working Group" and of the conclusions reached at that time. The operational modes were divided into three broad classes: classical observing, remote observing and service observing. The respective advantages and disadvantages were discussed and, at that time, the conclusion was reached that all three modes would be necessary. To allow this, it was important, in the conception of the VLT, that no essential options be designed out and that innovative ideas be incorporated. Now, it is more and more evident that flexible scheduling will be a central feature in the VLT operations, implying service observing. However, only the experience acquired with the NTT and then with the VLT will allow to select the most efficient ways of observing and, most probably, the VLT operations will start with classical modes.

M. Zolver reviewed the recent progresses made at ESO on the knowledge of seeing statistics and on the possibilities of seeing prediction. On the latter, three methods are presently investigated: statistical analysis, models of the atmospheric motions and warning from a station located ~ 30 km ahead of the observatory in the dominant-wind direction. Worries about the effect of levelling the Paranal summit on seeing quality were expressed in the audience; in fact, as seen through modelling of the atmospheric motions around the summit with its new profile, the effect should not be significative.

J. Breysacher described the present situation of time allocation at ESO. With 13 telescopes (including SEST) and 34 instrumental configurations, scheduling is a complex task. Many constraints of different nature (astronomical, logistic, human, etc.) have to be fulfilled. One simple change in the planning may lead to its complete revision. In these conditions, flexible scheduling cannot be introduced straightforwardly. Nevertheless, it is presently tested on a limited basis at the NTT so that experience might be acquired. It is already apparent that the changes of instrument must be done rapidly (in a few minutes) and reliably, that the standard procedures for calibration have to be revised and that expert systems which incorporate all the constraints have to be developed. Flexibility should not create inefficiency.

The following contribution, by Mrs. Becker (from the Institut National des Télécommunications), was along the line of expert systems. She reviewed the present situation of queue managing, a completely new topic for most of us, but with which we might have to get familiar if we are to observe in the years 2001 on large instruments.

C. Boisson reported on her experience with service observing at the British telescopes. She explained that this service requires from the potential users a very detailed preparation of the observations and from the organization which offers it, a corresponding staffing.

D. Baade reviewed the experience acquired at ESO in remote observing. From his talk, it was evident that remote control is already a reality, successfully managed at ESO. Several questions were raised by the audience, mainly on the actual performances of this mode of observations. In the case of the CAT+CES, the users are presently requesting more remote observing than can be handled at ESO Headquarters due to various constraints (~50 % of the nights). This example illustrates that remote observing is a competitive and successful mode of observation.

D. Alloin discussed the coordination of programmes on an international basis. The nature of some astrophysical questions to which we are faced today is such that their handling requires the effort of a very large astronomical community. She insisted on the potentiality offered by the new electronic devices and on the fact that their optimal use allows nowadays world-wide collaboration in an easy way.

More specifically, J. Clavel described an example of an internationally coordinated observing programme with IUE. This coordination allowed the proposers to perform observations that they would not have been able to conduct individually through standard procedures. These two talks stimulated various reactions from the audience. The main point of both speakers was that, in some cases, there is no other means to tackle fundamental problems that can be solved today thanks to the technological progresses. Later in the day, stellar seismology was quoted as a field in which an international collaboration is essential for obtaining the necessary continuous time-coverage.

Through several examples, M. Crézé demonstrated the necessity of archiving data. His talk was followed by a vivid discussion about the nature of what should be archived. Everybody agreed that we should save the scientific outputs aimed at originally. The CORAVEL experiment was mentioned in that respect; its condensed output is considered as a key to its renowned efficiency. But should we also keep what we might, in the light of new developments, need in the future? ... At that time the spectre of Sk –69°202 was haunting the auditorium...

A talk centred on the interferometric mode of the VLT (VLTI) was presented by J.-M. Mariotti. It is clear that this very complex mode of observation will require a coordination in the observing programmes to obtain an optimal and efficient use of the VLTI. Before the 4 T8m can be coupled for interferometry, the 2 to 3 auxiliary movable telescopes (VISA) will be used on Paranal. Already, this mode will require on the site a very competent scientific staff specialized in interferometry.

A. Omont discussed some scientific projects which need the full dedication of a telescope, in general now considered as small (D ≤ 2 m), and which have a strategical interest for the development of astronomy. As an example the 2-μm survey of the southern sky was described (DENIS). This programme has been accepted recently as an ESO Key Programme by the OPC and requires the use of the existing 1-m telescope on La Silla more than 50 % of the time during at least three years. DENIS will produce a complete coverage of the southern hemisphere with a spatial resolution of 3″ down to I ~ 18, J ~ 16 and K ~ 14. In continuation, A. Omont advocated the construction on Paranal of a modern-technology small-size telescope dedicated to deep wide-field imagery in the near-infrared range (1–2.5 μm) as has already been proposed by some members of the DENIS team.

A. Blanchard discussed possible uses of the future medium-size telescopes (D ~ 2 to 4 m). He demonstrated the need of wide-field multi-object spectroscopy for cosmological programmes. In this respect, the already existing 4-m-class telescopes are well suited and will stay competitive in the era of the T8m.

Then, a panel discussion chaired by P. Léna was held. Intervenors were J. Beckers, R. Cayrel, J. Clavel, J. Lequeux and L. Woltjer. P. Léna himself opened the discussion. He recalled the cost of the new equipments and the volume of data that they will produce. He urged astronomers to rationalize their programmes and to increase the productivity of the instruments they use by a proper distribution of the outputs.

J. Beckers talked about the complexity of future telescopes and especially of the VLT which will be different from all other existing telescopes including the NTT. In addition, the VLT may evolve in the direction of even more complexity. For instance, adaptive optics is foreseen today only at the primary coudé, but we cannot afford in the future not to have it at the other foci; furthermore, artificial reference stars appear now available, so that they will certainly be requested. In short, it means that we will be dealing with a "whole new age of telescopes" that must be operated differently from before. From this follows the requirement to have on the Paranal site a very competent and dedicated staff. Solid programmes of maintenance and check-up will also be required. The conditions are necessary to assure that the systems are working at best when they are used by or for scientists. Of course, similar conditions are also necessary to maintain the competitivity of the other, conventional, ESO telescopes and hence to allow for the justification of activities on La Silla till or even beyond 2001.

R. Cayrel called for a revolution in the astronomers' habits, in their relations with the data-acquisition procedures. The ever-increasing complexity of modern instruments and telescopes is intractable for a scientist observing 3 or 4 nights each year, and sometimes less. For example, the introduction of adaptive optics which will produce a considerable gain in the performances of modern telescopes or the development of the interferometric mode will require the permanent presence of specialists on the Paranal site. All these specialists will have to interact strongly with the users. Some must be themselves scientists with an instrumental speciality. Also, a standardization of the observing procedures will be necessary to avoid duplication of the calibrations and to improve their quality. Finally, R. Cayrel called for an effort towards a more solid conversion of astronomical units into physical ones!

J. Clavel brought the assistance back to space. He cautioned us to be very careful at organizing well in advance the management of observatories in their routine phase and at setting on time proper media for data processing. Finally, he spoke about the development of ESIS whose mission is to archive and distribute scientific data in Europe.

J. Lequeux intervened at that time and reminded the audience that publication in scientific journals is a way of saving data of importance for the future. Paper is still the most permanent support for archiving. On the other hand, access to the relevant data is not always easy as they are not stored digitally. He advocated the evolution of printed journals towards digitally-supported and electronically-distributed journals (see also *The Messenger* **67**, p. 58).

As a conclusion, L. Woltjer summarized some of his ideas. He insisted

H.-W. Marck 1914–1992

We received the sad news that Mr. Hans-Werner Marck, accountant at ESO from 1963 to 1976, died on 25.1.1992.

Mr. Marck was in the early days of ESO a close collaborator to the Manager, Mr. J. Bloemkolk, and was in charge of all financial and accounting matters at the beginning of the Organization until the relocation from Hamburg to Munich in 1976.

on the importance of professionalism. State-of-the-art equipment might be better operated by experts in astronomical observations, rather than by astronomers visiting on short stays. Also, he stressed that the major cost in running an observatory is not due to the telescopes and the instruments, but rather to maintaining the infrastructure. Therefore for the year 2001, he advised to move (or replace) the La Silla telescopes to Paranal. Finally, on the subject of data archival, although agreeing with its necessity, he cautioned the community against doing like these scholars who, for centuries, only studied "archives" from the Antiquity...

In the present report, it is not possible to reproduce even coarsely the lively discussions that we had throughout the whole day. Enough to say that it was very difficult to keep on schedule! After all, these vivid exchanges were demonstrating the interest and motivation of the participants. The proceedings of this forum have been edited and are available on request to the organizers. They contain the contributions of all speakers and a complete transcription of the panel discussion.

The Sonneberg Plate Archive

H.-J. BRÄUER and B. FUHRMANN, Sternwarte Sonneberg, Germany

Sonneberg, until recently behind, and only a stone's throw away from the Iron Curtain, is no longer shut off from the outside world. Its observatory is restored to the international astronomical community, and the community ought to know what it has gained. Above all it now has access to the world's second largest plate archive and an intact photographic Sky Patrol. Its series of recordings reach back into the past as far as 1926. Sonneberg (240,000 plates) excels the Harvard collection (400,000 plates) in the continuity of its recordings and in the machine-readability of the archival data.

There is, however, a drop of bitterness. In the face of a present uncertainty about the future of Sonneberg Observatory, the IAU felt compelled to recommend, in a resolution of Commissions 27 and 42, that "all efforts be undertaken to continue these important measurements and to ensure the appropriate maintenance and availability of the data archives" (*IAU Inf. Bull.* **67**, 39–40 (1992)). In accordance with this recommendation, the Sonneberg team leaves no stone unturned in avoiding any gap and preventing a premature discontinuation, and is grateful for every support in its endeavour.

CCDs are advancing on patrols, and in the near future they will be big enough to take over after the photographic plates. But on no account must photography be discarded before a smooth transition is achieved. Then, once the CCDs can be used, patrols can be automated, and it is necessary to run them in a climate better than that in Central Europe. A new responsibility might then accrue to ESO, too.

Sky Patrols aim at providing a continuous record of the sky. Not only do they lead to discoveries of time-variable objects, but they allow the investigation of objects retrospectively. The first time the Sonneberg collection became a talking point was when, in 1937, the Minor Planet Hermes came extremely near to the earth and the Sonneberg patrol provided data for the orbital determination. Other instances, just to

Table 1: *List of fields regularly covered by the Sonneberg Field Patrol routine. R.A. and Decl. give the position of the field centres, N the number of plates archived.*

Coordinates (1950)			Coordinates (1950)			Coordinates (1950)		
R.A.	Decl.	N	R.A.	Decl.	N	R.A.	Decl.	N
$0^h06.5^m$	+58°52′	415	$6^h41.0^m$	+ 3°59′	344	$17^h66.8^m$	+29°15′	340
0 47.0	+40 48	409	6 51.8	+13 15	298	17 58.1	+ 2 56	373
1 06.9	+35 21	372	6 53.9	−16 59	260	18 18.1	+36 02	473
1 16.9	+57 58	403	6 59.5	− 5 39	226	18 41.5	+ 8 34	265
1 38.8	+29 48	325	7 31.5	−14 25	240	18 52.2	+27 51	243
1 57.8	+70 40	258	7 36.7	+ 5 31	240	18 53.8	+43 53	574
2 04.3	+23 14	159	8 05.4	−24 10	144	19 15.9	+53 17	298
2 06.6	+34 45	356	8 52.8	+ 6 08	413	19 23.0	+ 3 01	550
2 21.7	+56 23	313	9 29.5	+51 54	124	19 37.4	+30 02	424
3 02.0	+38 39	413	10 05.7	+12 13	184	19 43.9	+10 29	376
3 20.7	+49 41	349	11 06.9	+44 46	409	19 56.6	+19 21	432
3 51.0	+31 44	110	11 21.3	+10 48	470	20 01.8	+ 0 51	388
4 11.2	+48 17	259	11 38.2	+21 38	168	20 12.2	+56 25	371
4 24.3	+22 53	128	11 45.4	+20 30	353	20 19.5	+30 26	243
4 36.7	+39 42	271	12 09.6	+20 49	286	20 20.4	+40 06	346
4 52.1	+10 04	98	12 30.5	+10 34	315	20 35.2	+14 25	391
5 05.4	− 5 09	197	12 36.6	+21 20	289	20 56.5	+44 17	346
5 13.0	+34 15	233	12 51.0	+19 45	92	21 28.0	+70 20	130
5 34.2	+ 9 16	381	13 38.3	+20 12	292	21 32.1	+45 22	368
5 44.5	+17 43	301	16 28.1	+21 36	383	22 19.0	+46 17	495
5 50.2	+27 36	274	16 42.0	+34 08	736	22 21.6	+51 59	189
5 55.9	+44 57	440	16 55.3	+ 9 27	269	22 47.9	+65 05	221
6 03.9	−14 56	89	17 10.2	+45 23	199	23 08.9	+52 47	303
6 13.6	+12 17	233	17 22.0	+23 00	356			Total: 22704
6 26.0	+20 15	371	17 32.6	+12 36	318			

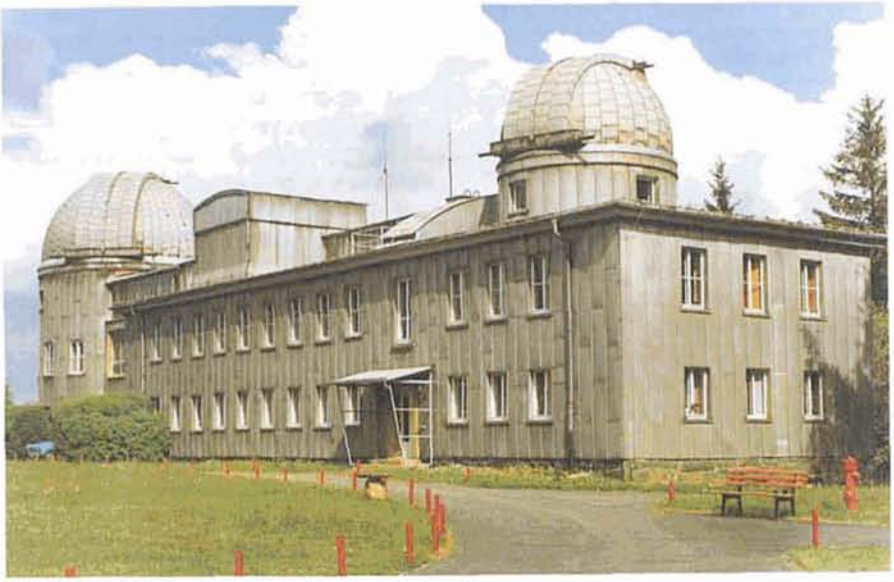

Figure 1: *The main building of the Sonneberg Observatory.*

Figure 2: *The sky patrol cameras.*

mention a few, were the quasar 3C273, whose light-curve – the first complete light-curve of a quasar ever to be established – was obtained mainly from Harvard and Sonneberg recordings, X-ray sources as the "Sonneberg X-ray star" HerX-1, or the two planetary nebulae NGC 2346 and 60-7°1. The nebula 60-7°1 (Catalogue of Perek and coll.) was to be a test case for stellar evolution, and its importance was compared to that of the Rosetta Stone for the decyphering of the Egyptian hieroglyphics. Its variability was discovered by C. Hoffmeister (Sonneberg; 1892–1968), who regarded it as being a variable star. In the late fifties G.A. Richter (Sonneberg) inspected recordings that had been made at Sonneberg in close succession since 1928 and, taking into account a few additional data from Cambridge/Mass. and Heidelberg from between the years 1890 and 1920, he recognized an exciting peculiarity. During the last 65 years the object had steadily grown brighter. Since 1890 it had risen 3.5 mag over its initial brightness of 13.2. The publication of its light-curve triggered a spate of investigations and subsequent theoretical studies all over the world. Among other things, high-resolution spectroscopy revealed that, from 1955 to 1976, its central star, FG Sge, had traversed the Hertzsprung-Russell diagram from the left (spectral type B4) to the right (spectral type G2) and that, in 1967, singly-ionized rare earths appeared, which five years later became so strong as to show about 25 times the solar abundance (Hoffmeister, Richter, Wenzel: Variable Stars, Springer-Verlag 1985).

It stands to reason that the existence of the Sonneberg plate collection is not due to mere waiting for unexpected events. It has been one of the cornerstones of the Sonneberg programme of variable star research. One quarter of all variable stars known in the Galaxy were discovered by means of its plates. The particular value of this collection consists in that it is an excellent stock of information for studying the long-term behaviour of active objects. Increasingly, it is supporting observations made from satellites at non-optical wavelengths. For the most part, though, the plates have been taken in the framework

Table 2: *Numbers of Sonneberg Sky Patrol plates taken during the last 30 years, distributed over 6 declination zones. Bars hatched: blue (pg), not hatched: red (pv). The petering-out of zone –20° is due to light pollution.* ▼

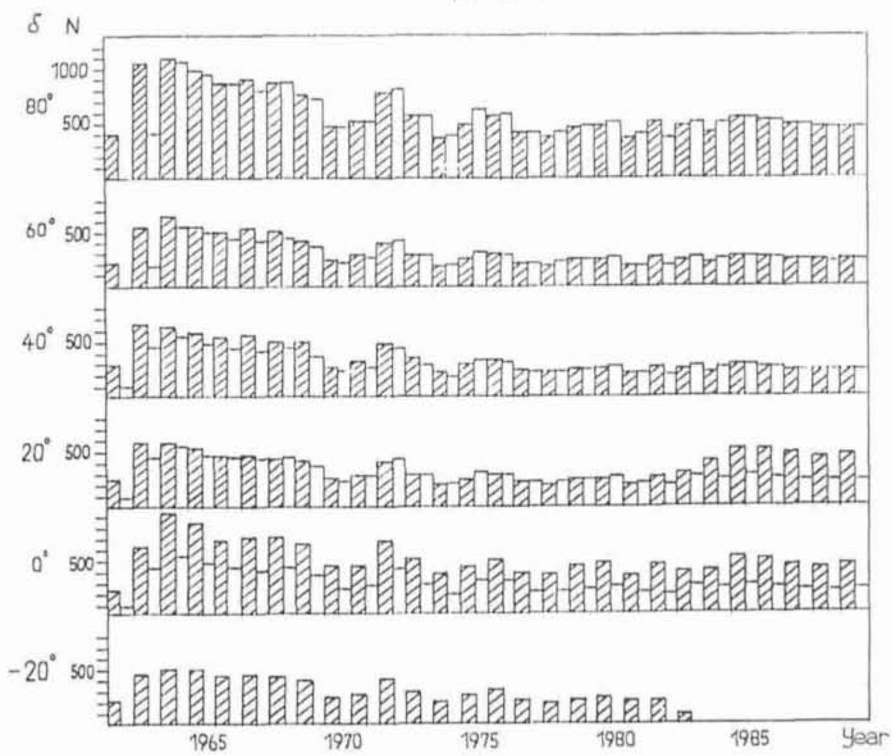

Table 3: *Cameras used by the Sonneberg patrols. The last column gives their years of service.*

	Plate limit	Field size	Plate dimension	Number of plates	Years
Schmidt Telescope 500/700/1720 mm	18.5 (B)	3.8° × 3.8°	13 cm × 13 cm	8900	since 1952
Astrographs 400/1600 mm 400/2000 mm	 17.5 (pg) 17.5 (pg)	 10° × 10° 8° × 8°	 30 cm × 30 cm 30 cm × 30 cm	 12200 6900	 1938 – 45, since 1961 since 1960
Sky Patrol 14 cameras 55/250 mm	 14.5 (pg) 13.5 (pv)	 26° × 26° 26° × 26°	 13 cm × 13 cm 13 cm × 13 cm	 93000 51000	 since 1956 since 1958
Several instruments: formerly used Field Patrol Sky Patrol foreign				 16000 43600 8400	
Total				240000	

of the Sonneberg Field Patrol (Felderplan) and the Sonneberg Sky Patrol.

The Field Patrol aims at recording, in every clear night, 81 fields selected along, or near the northern Milky Way with astrographs; it was started in the mid-twenties by C. Hoffmeister. Table 1 gives a list of the fields most regularly recorded, and the numbers of plates taken. The Sky Patrol – going back to an idea of P. Guthnick's (1879–1947) – is a programme covering the entire northern sky in two colours with 14 short-focus cameras on two mountings. Table 2 shows in diagrammatic form how the plates taken in blue (pg) and in red (pv) during the last 30 years are distributed over the declination zones. Details about the instruments are given in Table 3.

On May 1, 1992, the number of plates of the Sonneberg vault totalled 240,222, not counting about 1200 older plates of uncertain identity with respect to camera, time of exposure, or coordinates of the field, etc. The annual increase has been 4500 recordings on average.

About 80 % of the plate data are archived and retrievable. The 20 MByte database consists of record files, each record containing information on one plate such as date and time of exposure, object or field recorded, photographic emulsion, sensitivity, filters, state of the sky, observers' comments, etc., a number of auxiliary files, and programmes for management and user. For the digitization of the photographic information on the plates themselves, a made-to-order, time- and cost-saving configuration using a 12-bit CCD line scanner has been invented and tested in cooperation with the Institut für Theoretische Astrophysik of Tübingen University. Comparative measurements were performed at the Garching PDS of ESO. Operation at Sonneberg, however, has hitherto been stalled by hesitating custodians of public funds.

Although its plate vault is still lacking computer-aided measuring devices, visitors to Sonneberg Observatory are always welcome and can readily profit from its wealth of information using its conventional equipment. The small Sonneberg staff, severely pruned by recent reforms in former East Germany, are doing their best to become a fully-fledged member of modern society soon.

A Scrutiny of HD 62623 and HD 96446

L.O. LODÉN, Astronomiska Observatoriet, Uppsala, Sweden

There has been a general consensus that CP A stars are all near-main-sequence objects. If so, the chemical peculiarity might be a valuable luminosity criterion, useful, for instance, in connection with optical soundings in the Milky Way. In reality, however, the situation seems to be a little bit too complicated for practical application. Firstly there is an awkward fact that a considerable amount of peculiar features observed in (upper main-sequence) stellar spectra already coincide with well-established luminosity-classification parameters – although in the "wrong sense", i.e. some spectral lines typical for CP stars, tend to show a positive luminosity dependence. Secondly, there is a non-ignorable number of stars, classified as both peculiar and giants, or even supergiants, particularly in the Michigan Catalogue.

In a series of previous contributions, the authors have made attempts to reclassify a selection of such objects in order to either confirm or refute the "double" or "contradictory" classification of them (Lodén-Sundman 1987, 1989, Lodén 1990). In no case the result became definitely conclusive, but, for certain objects, there was no indication whatsoever of any combination of peculiarity and high luminosity. Some of them behaved in an awkward manner indicating neither "traditional" peculiarity nor particularly high luminosity. Rather there might be reason to suspect a superposition of two spectra, the appearance of which could give reason to misclassify the luminosity or the attitude of chemical composition or both.

The main result of the investigation was that a possible admixture of peculiar A-type stars in the observational material does probably not imply any enhanced risk of distance misdetermination at optical soundings in the Milky Way.

Still, however, there are a few notorious stars which show a rather clear evidence of high luminosity and peculiarity of some kind as well, albeit this peculiarity may not always be considered as "traditional" in terms of enhanced Si, Sr, or Eu abundance. A few of these stars have now been subject to a more inquisitive study. The basis of the argument has been that if these stars could also be shown to be, in reality, rather normal, then it will probably go for the other ones too. The observing thesis would not be valid, however.

The targets of the present investigation are HD 62323 and HD 96446. The basic data for them are shown in Table 1.

Table 1.

Star	R.A. (2000)	Decl. (2000)	V	B-V	U-B	Sp.*
HD 62323	7h 43m 48.4s	−28° 57′ 18″	4.16	0.18	−0.01	A2 Iabp
HD 96446	11h 6m 5.7s	−59° 56′ 59″	6.68	−0.15	−0.82	B2 IIIp

* according to literature

The Observations

All observations relevant to the present report have been performed at La Silla. Photometric photometry was obtained with the 50-cm ESO telescope in 1988. Spectrographic plates were taken with the coudé spectrograph of the 1.52-m telescope in 1987 and echelle spectrograms with the same telescope in 1988 and 1991. The dispersion ranges from 3.1 Å/mm at 4000 Å to 4.5 Å/mm at 5500 Å. The reduction of the CCD echelles was performed at ESO Headquarters in Garching during the first part of August 1991.

HD 62623

This star has been subject to particular interest for a long time, and a series of papers dealing with it have been published.

The contributions generally concern identification of lines in the spectrum and also calculation of the atmospheric abundance of certain elements and estimation of the effective temperature and luminosity of the star.

In the present investigation the basic issue was to reveal possible systems of lines with radial velocity displacement deviating from the majority of lines and thus suggesting the presence of a companion star. About 500 lines have been identified and the 80 most certain ones selected for radial velocity calculations. The result clearly indicates that no single line or system of lines, within the limits of accuracy, show any significant deviation from the average value. It also shows that this average value, after correction for terrestrial motion, is completely unchanged during the run of the actual five observing nights. It is estimated to 28.7 ± 0.2 km/sec.

Hence there is no indication of a composite spectrum for this star. The apparently peculiar appearance of its spectrum might, at least partly, be explained as an accidental combination of high luminosity and very low *v sin i* value.

HD 96446

The study of this object is considerably more complicated than the corresponding study of the previous one. Particularly the technical circumstances are less favourable. As HD 96446 is fainter, the disturbance from the noise becomes more important, as well as the production of false lines, one of the major problems with the ECHELEC spectrograph at ESO. The identification of the lines in the spectrum of HD 96446 is also difficult as a consequence of the fact that many low-temperature lines, with or without mutual displacement, tend to appear very close to the position of certain high-temperature lines. A serious drawback at the study of any type of stars with the actual equipment is that one cannot record the whole spectral range at one and the same exposure. As it is not permitted to change the spectral region during a night, it is then impossible to follow the position of a certain set of lines from night to night without inconvenient restriction of the spectral range. Also the consequences of this circumstance were particularly harassing in the case of HD 96446.

At the actual observations in 1991, the total spectral range was split up into the following partial sections:

1. 3867 – 4153Å February 2
2. 4075 – 4390Å February 1 and 5
3. 4296 – 4622Å February 3
4. 4552 – 4863Å February 4

The conclusions concerning possible multiplicity are, because of the circumstances mentioned, less convincing for HD 96446 than for HD 62623. There is no palpable or unique indication of a component, only a series of vague vestiges. The following ones are to be mentioned.

1. A weak photometric variability. Spectrum variability has been reported by Pedersen and Thomsen [1977] and Kaufmann and Theil [1980].
2. Presence of a few spectral lines, characteristic for an atmosphere of considerably lower temperature.
3. A tendency for certain spectral lines to appear as double.
4. A corresponding tendency to show a Doppler displacement, significantly different from the average value for all lines.
5. An apparent symbiosis of sharp and structured lines in the spectrum.

These observations require some comments which are, in fact, highly important.

1. The light variation (Fig. 1) is not particularly well pronounced and it has probably nothing to do with any

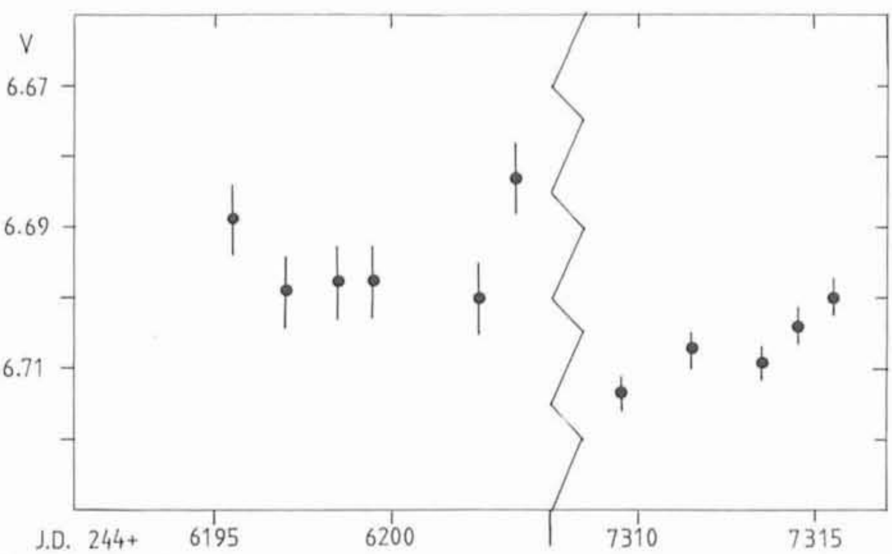

Figure 1: *UBV photometry of HD 96446 from two different occasions, 1985 and 1988. The accuracy in the measurements was higher at the last one. The overall impression is, of course, that the star is fairly stable. There is some reason, however, to suspect that the small variations visible are significant.*

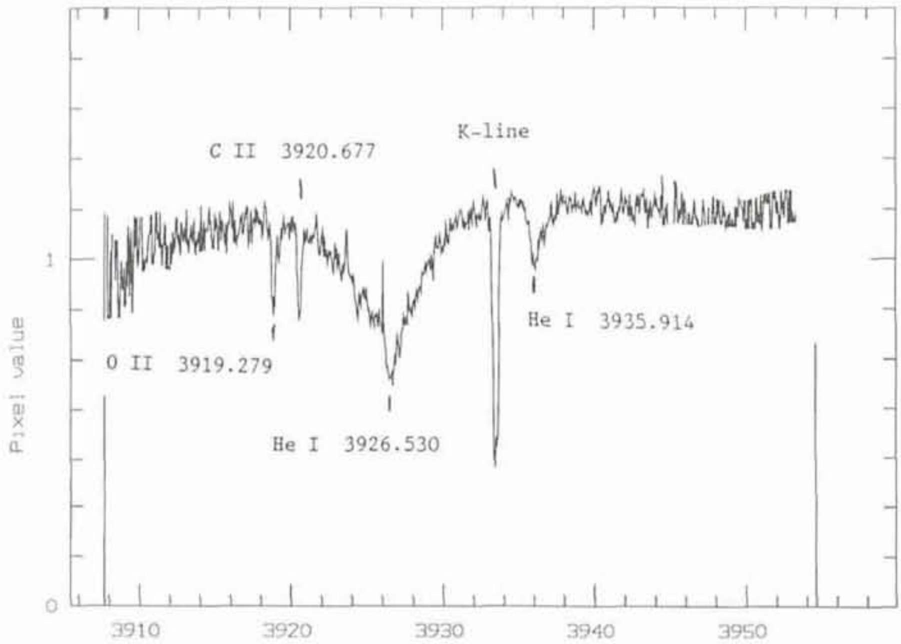

Figure 2: *A section of an ECHELEC spectrum of HD 96446. Most spectral features visible here seem to be real.*

eclipsing phenomenon. Rather it might indicate an intrinsic variability, not characteristic for early-type stars. It has to be noted, however, that, when observed on different occasions with considerable time-separation, the mean value of the photometric parameters has turned out to be constant. Thus the UBV mean values obtained from 7 nights in 1985 are: 6.696, −0.151, −0.823 and the corresponding ones from 5 nights in 1988: 6.705, −0.155, −0.826. The possible He-line variations, mentioned above, are actually not relevant and, besides, the routines of the CCD-ECHELEC reduction do not permit any high-accuracy measurements of line intensities.

2. Typical examples are some Fe lines crowding between 3935 and 3936 and some mysterious lines (Ti I?) around 4099. In an extensive contribution by Wolf (1973) a large number of "high-temperature" lines are identified. Unfortunately it is not self-evident that all lines found in a certain position really and entirely represent the expected ones. The lines themselves do not tell you explicitly who they are. As mentioned above, there are quite a few coincidences between high and medium lines in the spectrum without any possibility of convincing unbiased identification.

   In Table 2 I have added some identified high-temperature lines to the list, presented by Wolf. Besides, however, there are a few lines which I personally consider as not characteristic for a B2 star although another series of observations with still higher resolution is required for definite confirmation.
3. The H and K lines seem to be of interstellar origin. With respect to the star's location in the Milky Way one has to expect a considerable con-

A Panorama of La Silla

H. ZODET, ESO

The centrefold in this *Messenger* issue was obtained in late December 1991 and depicts the central part of the 180° panorama reproduced below.

It shows the La Silla observatory and most of the telescopes there, just before sunset. It was taken from the road that leads to the 3.6-m telescope. Quite a few cars with busy astronomers and engineers passed me and probably wondered what a photographer was doing there, with plenty of equipment in the middle of the road. Thanks for their kind consideration, a minor traffic jam was elegantly avoided.

This panorama covers half of the horizon and is a composite of eight individual exposures, made in rapid succession so that the illumination would not change too much.

I used a Hasselblad 2000FC camera, equipped with a Zeiss Planar 110-mm lens, stopped to 1:2. The film was Kodak Ektachrome 100 Plus.

In order to combine the slides so that there would be a smooth transition between all of them, they were scanned and re-assembled electronically by Reger Studios, Munich.

This photo is one of a series of panoramic views of the ESO observatory, which I obtained from various locations in and around La Silla. It turns out that due to the pattern of the telescope domes, there does not exist any spot (on the ground at least) frome where all buildings are simultaneously visible.

The La Silla Panorama which is well suited for the production of horizon panoramas in Planetaria, etc., is now available from the ESO Information Service (address on last page). It may be obtained as a 1-metre-long photographic print or a 24-cm-wide slide, both at a cost of 115 DM. Please be sure to indicate on the order which of the two is desired.

tribution from the interstellar matter. There should be noted, however, that the UBV colour excess looks surprisingly low and a certain caution would be appropriate. Furthermore, the H and K lines are slightly doubled, and the Doppler displacement for one of the components apparently coincides with that for the majority of the assumed stellar lines. In other cases of double-line appearances it is probably near at hand to interpret the phenomenon as a disturbance from a ghost rather than from a real Doppler shift.

4. Also in cases where a single line tends to show significant individual Doppler shift, one should in the first instance suspect some kind of blend effect.

When time-variation of the Doppler shift is concerned, there are certain differences between the mean values for the various nights of observation but, unfortunately, the overall accuracy is not high enough to convince us with certainty that these differences are really significant. The average radial velocities obtained were (when corrected for terrestrial motion)

May 28, 1988	+ 4.98	±2.75
30	+ 2.03	±2.45
31	+ 7.00	±3.00
Feb. 1, 1991	+ 8.48	±1.00
2	+ 8.64	±1.52
3	+ 8.97	±0.90
4	+ 7.85	±0.80
5	+10.43	±0.80

As can be seen from the scattering figures, it is hardly advisable to draw any conclusions about long-term variations in the radial velocity, but a very careful study of a few selected lines has given an indication that the relative difference between February 1 and February 5 might be significant.

Well, the present study of the two stars has not led up to any exciting result or definite answer to the question about their possible multiplicity. Epitomizing, however, one could at least vindicate that HD 62623 is probably alone and that HD 96446 is still under serious suspicion of having a baffling component. In no case, of course, we can exclude the possibility of a malicious component moving nearly perpendicular to the line of sight.

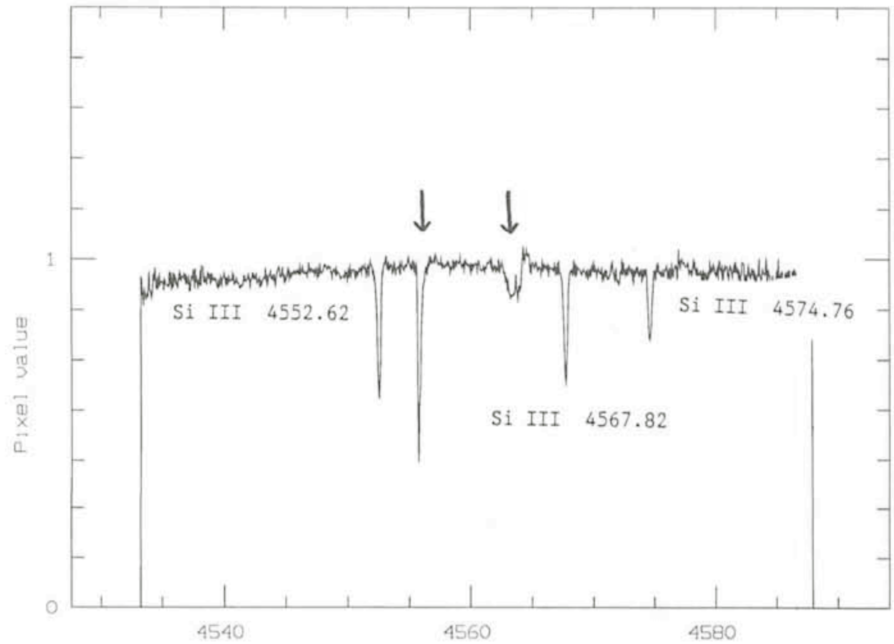

Figure 3: *Another section of an ECHELEC spectrum of HD 96446. Here one can see two characteristic delusive spectral features, produced somewhere in the system (arrows).*

The project itself has been very interesting to carry out and particularly the experience from the use of the ECHELEC spectrograph has been stimulating. Possibly one could object that the reduction procedure with the observational material is a little bit too complicated and time consuming, as well as computer space consuming, in consideration to the outcome, and that the occurrence of false spectral features is still unreasonably frequent.

I am most grateful to Pascal Ballester for his devoted and competent assistance at the reduction of my tapes during a couple of hectic weeks at the ESO Headquarters in August 1991.

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Table 2: *List of high-temperature lines, identified in the actual investigation but missing in Wolf's list (1973)*

3919.279	O II	4092.94	O II	4345.56	O II
3955.851	N II	4095.63	O II	4351.275	O II
3973.266	O II	4110.79	O II	4369.28	O II
4016.104	Si IV	4112.02	O II	4673.71	O I, II
4062.94	O II	4137.63	N I	4677.94	N II
4071.24	O II	4169.23	O II	4703.14	O II
4073.04	N II	4294.74	O II	4788.126	N II
4084.66	O II	4303.78	O II	4803.272	N II
4088.863	Si IV	4336.85	O II		

STAFF MOVEMENTS

Arrivals

Europe

CLÉVA, Frédéric (F), Coopérant
LOUSTALOT, Florence (F), Secretary to the Head of Administration
MARCONI, Gianni (I), Fellow
MEYLAN, Georges (CH), Astronomer
QUENTIN, Jutta (D), Draughtswoman (Mechanics)

Departures

Europe

BEELEN, Guido (B), Electronics Engineer
DOBBELS, Geert (B), Remote Control Operator
HES, Ronald (NL), Student
WANG, Li-fan (RC), Associate

Chile

HAINAUT, Olivier (B), Coopérant
HAINAUT-ROUELLE, Marie-Claire (B), Associate
HEYDARI-MALAYERI, Mohammad (F), Astronomer

On the Optical Counterpart of PSR 0540-693

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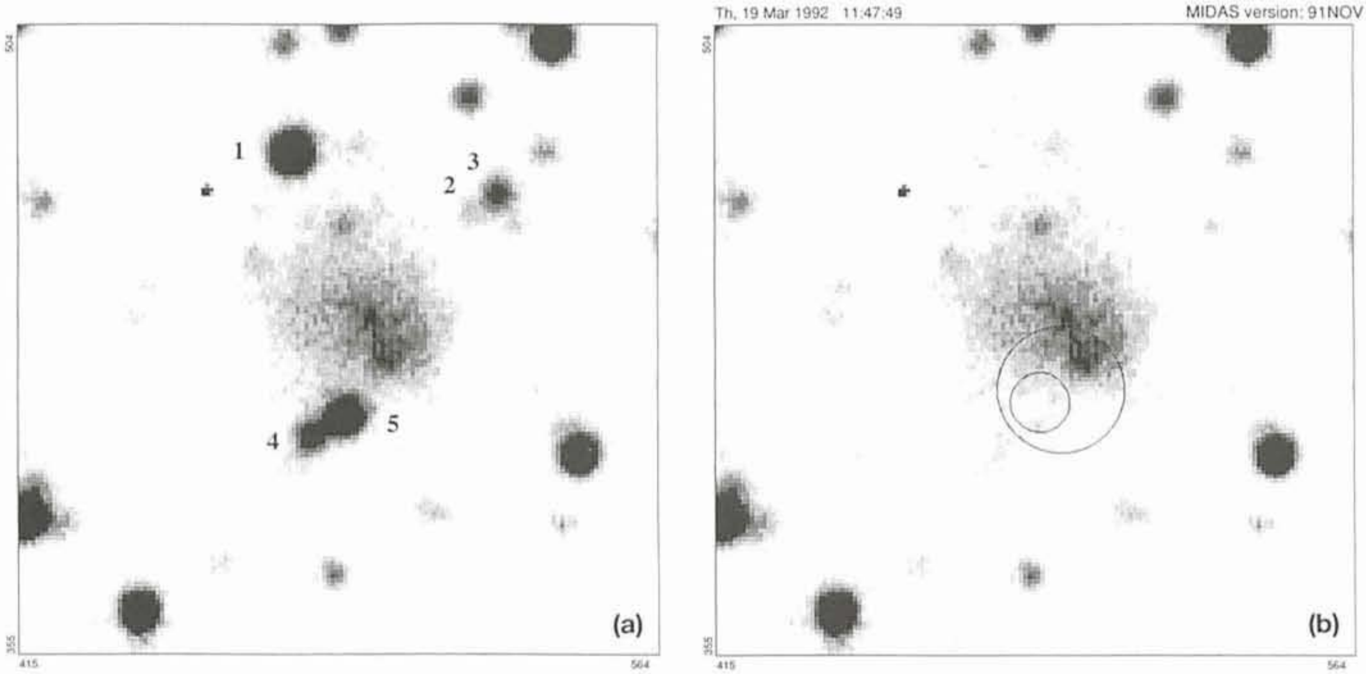
Part of the remnant of the penultimate known supernova explosion in the Large Magellanic Cloud, PSR 0540-693, is the only "classical" young pulsar not seen in radio because of its distance. Nevertheless, X-ray and optical studies of this object, as well as of the surrounding SNR, classify it as the most striking example of a Crab-like SNR-pulsar association.

Like the Crab, SNR 0540-693 does contain a $\nu^{-0.8}$ power-law spectrum radio to X-ray synchrotron nebula (Chanan et al., 1984, Clark et al., 1982), where the Einstein Observatory discovered the 50-msec pulsation of PSR 0540-693 (Seward et al., 1984), contributing ~23 % of the total unresolved X-ray emission. Although below the current detectability limit of the southern hemisphere radio telescopes, the object has been seen as an optical pulsar (Middleditch and Pennypacker, 1985; Middleditch et al., 1987) with B and V magnitudes ~22 and colours slightly redder than those of the Crab pulsar.

After Crab and Vela, PSR 0540-693 is thus the third pulsar detected as a fast pulsating optical source.

However, partly because of the lack of precise position (usually computed from long-term radio timing data) and partly because of lack of high-resolution



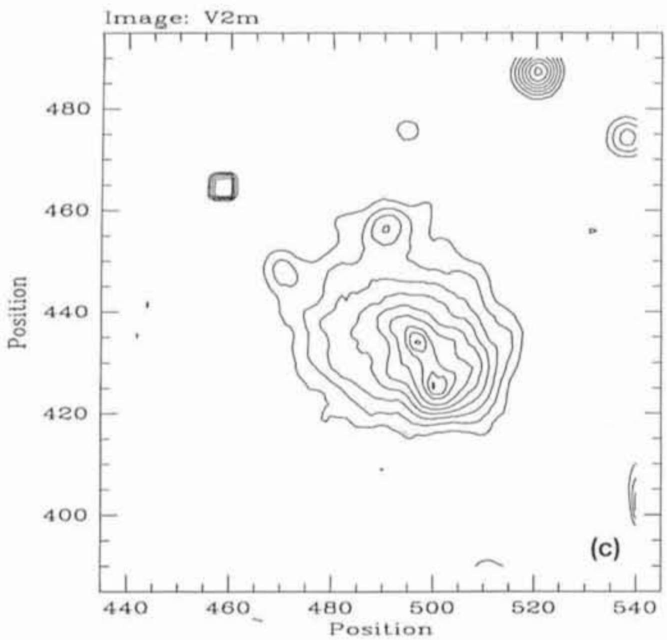


Figure 1: *Data analysis sequence for the 2-minute V filter image of SNR 0540-69 in LMC, taken at the ESO NTT under sub-arcsec seeing conditions. North is up, east at left.*
(a) raw data after flat fielding. The star images visible near the SNR are labelled 1-5. The SUSI/NTT pixel size is 0.13". Frame scale in pixels.
(b) as (a), after subtraction of stars 1-5. The 4" diameter error circle represents the HRI position of the Einstein X-ray pulsating source 1E 0540.5-6921, while the 1.8" diameter circle has been computed by Manchester and Peterson (1989). Of the two maxima observed, the northern (central) at the boundary of the X-ray circle, appears more compact and is our proposed counterpart for the 50-msec pulsar.
(c) Isophote map of (b). Low flux contour to the north-east of the remnant could arise from unrecognized faint field stars.

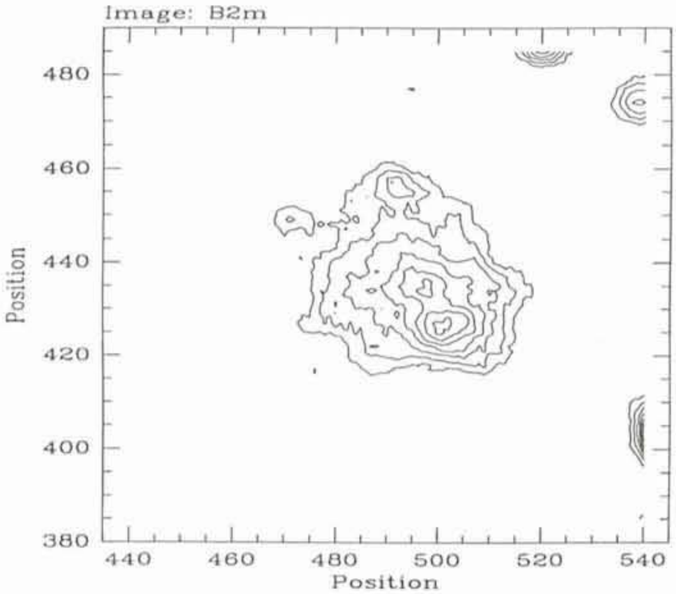


Figure 2: *Isophote map, after subtraction of stars 1-5, of the 2-minute B filter image.*

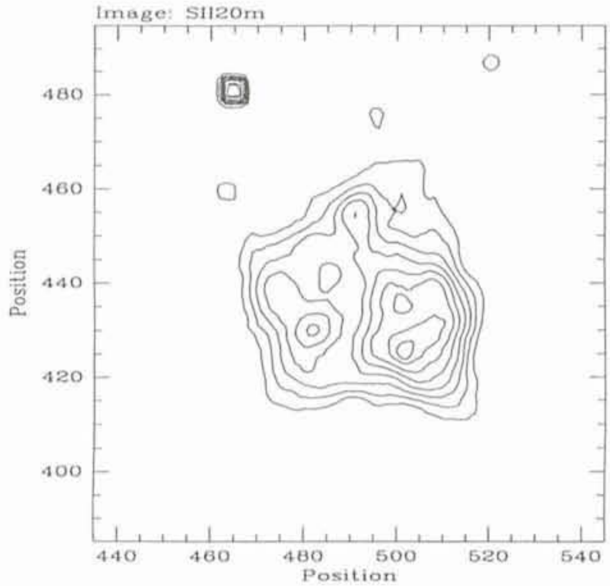


Figure 3: *Star subtracted isophote map of 20-minute SII (λ=6728 Å, $\Delta\lambda$=59 Å) image.*

optical data, it has so far been impossible to optically identify its counterpart against the background of the synchrotron nebula.

With an angular diameter of ~10″ and an integrated diffuse emission far brighter than the pulsing source, PSR 0540-693 and its Synchrotron nebula are indeed a challenging target for high-resolution imaging.

Nevertheless, in the absence of a radio signal (a condition unique to this object), the optical identification would be the *only* way to know its precise position. This is a critical piece of information for long-term temporal studies, such as the measure of the braking index, a key parameter for the understanding of the pulsar emission mechanisms, known, so far, only for PRS 0530+21, the Crab pulsar, and PSR 1509-58, the "150-msec" pulsar. The Crab-like young pulsar PSR 0540-693 would indeed be a prime candidate for a precise measure of the braking index because of its high $\dot{P}$. The results are, however, inconclusive, mainly because of the uncertainties induced by the ± 2″ positional error in the barycentrization of the pulsed photon arrival times, a procedure needed to phase correctly light curves collected at different epochs.

The resolving power needed to start on this problem has been provided by SUSI (SUperb Seeing Imager, pixel size of 0.13″ over a field of view of 2.2×2.2 arcmin) on November 1991, under sub-arcsec seeing conditions, as part of the ESO Key Programme 6-002-45K.

We obtained two 1-minute V exposures, one 2-minute B exposure, one 10-minute Hα (λ=6552 Å, $\Delta\lambda$=60 Å) exposure, two 10-minute and one 40-minute OIII (λ=5015 Å, $\Delta\lambda$=55 Å) exposures, and one 20-minute SII (λ=6728 Å, $\Delta\lambda$=59 Å) exposure, during two nights with seeing conditions varying from 0.6 to 0.9 arcsec.

The choice of filters was suggested by the previous imaging and spectroscopy work done on this object (Mathewson et al., 1980, Dopita and Touhy, 1984; Chanan et al., 1984; Kirshner et al., 1989). Our data-analysis procedure was as follows: after the usual cleaning and flat fielding, the five stellar images nearest to 0540 were subtracted in order to avoid their contribution to the diffuse structures, and a standard isophote image was constructed. Figure 1 (a, b and c) show such process for the V filter. The same star subtraction routine was than applied to the B as well as the narrow-band filter images, and the resulting isophote maps are given in Figures 2, 3, 4 and 5 for B, SII, OIII and Hα, respectively. The 4″ circle in Figure 1 represents the error region associated with the HRI X-ray source, 1E 0540.5-6921, located at $\alpha_{(1950)}$ = $5^h40^m33.9^2$ $\delta_{(1950)}$ = -69°21′23″.2 with the 2″ accuracy reported in the discovery paper by Seward et al., 1984. The nominally more accurate position, at $\alpha_{(1950)}$ = $5^h40^m34.03^s$ $\delta_{(1950)}$ = -69°21′23″.5, with a 0.9″ uncertainty, obtained by Manchester and Peterson (1989) on the basis of pulsar timing, has been added for completeness, in spite of later criticism by Nagase et al., 1990. Our astrometry was performed using several stars extracted by the Guide Star Catalogue and kindly provided to us by the User Support Branch of the STScI. We estimate its r.m.s. error to be less than 0.4 arcsec.

Two distinct maxima are visible inside the nebula in our B and V images, and the northern one appears more point-like. They are located, respectively, at $\alpha_{(1950)}$ = 5^h 40^m 33.84^s (± 0.5″) $\delta_{(1950)}$ = -69°21′20.9″ (± 0.5″), where the estimated error is mainly due to our astrometry, and $\alpha_{(1950)}$ = 5^h 40^m 33.78^s (± 1.0″) $\delta_{(1950)}$ = -69° 21′ 21.9″ (± 1.0″), where the estimated error comes mainly from the uncertainties in the centring algorithm.

Both positions appear compatible with the X-ray error box as well as with that of the 4.6″ diameter aperture used by Middleditch and Pennypacker (1985) to search for (and find) the optical pulsations.

Moreover, the B and V magnitudes of our two maxima are both compatible with the time-averaged values obtained

Table 1

	V filter	B filter
Northern maximum	22.4 ± 0.2	23.6 ± 0.3
Southern maximum	22.6 ± 0.2	23.0 ± 0.3
Pulsar (Middleditch and Pennypacker, 1985)	22.26 ± 0.20	23.15 ± 0.20
Pulsar (Middleditch et al., 1987)	22.38 ± 0.14	22.76 ± 0.23

The values reported in this table have not been corrected for interstellar absorption.

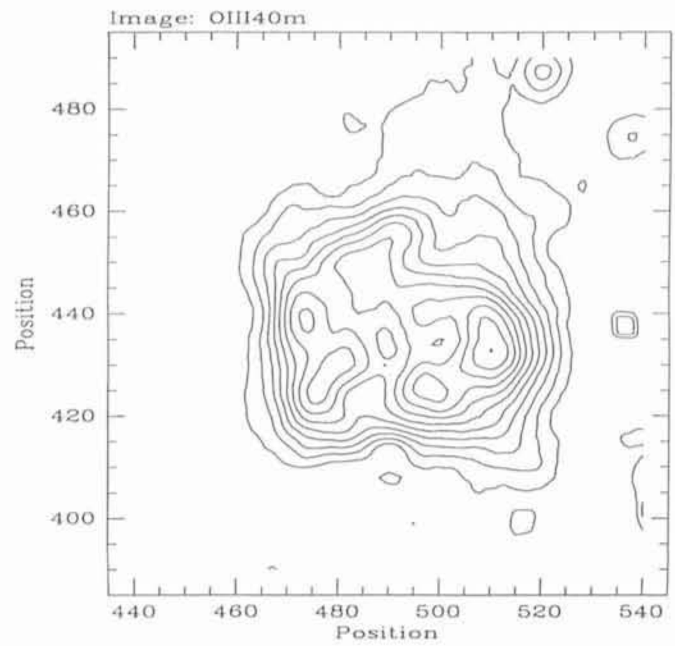


Figure 4: *Star subtracted isophote map of the 40-minute OIII ($\lambda = 5015$ Å, $\Delta\lambda = 55$ Å) exposure.*

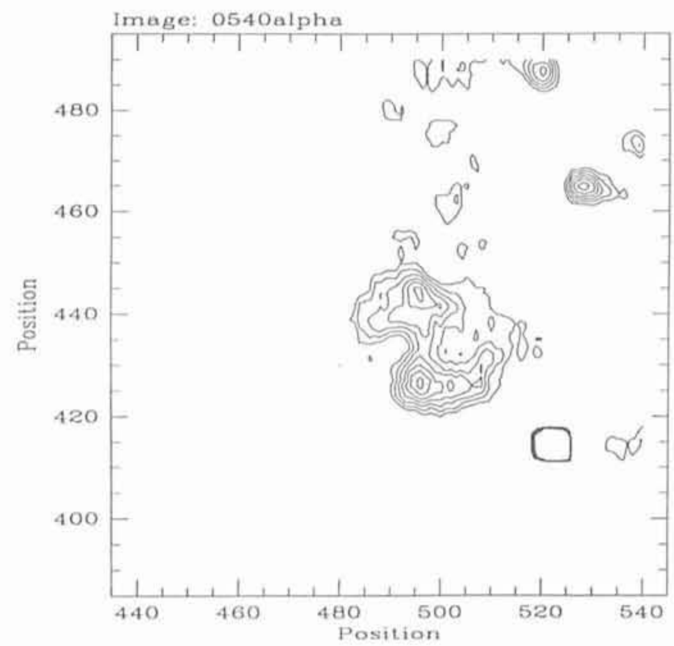


Figure 5: *Star subtracted isophote map of the 10-minute Hα ($\lambda = 6552$ Å, $\Delta\lambda = 60$ Å) image.*

during the fast photometry studies (see Table 1). This would imply for PSR 0540-693 a pulsed fraction near 100 %, to be compared with values of 75 % for the Crab and ~50 % for Vela. However, our magnitude estimates are uncertain because of the presence of the extended emission and any conclusion has to be taken with caution.

Besides identifying these two potential counterparts of PSR 0540-693, our data confirm the previous findings on the expanding shell as well as on the continuum synchrotron nebula. They also add considerable detail on the structure of both (see Caraveo et al. 1992 for a complete account of the results). The Hα image, not available in the literature so far, shows a structure smaller than that of the synchrotron nebula and with a totally different shape. The dimension of the "major axis" of the remnant, as seen in the different filters, varies from 9" in OIII to 7.5" in SII to 5.5" in the continuum to a bare 4" in Hα.

While our results on the dimension, shape and brightness of the remnant in B, V, OIII and SII come as no surprise, the Hα picture is somewhat intriguing. Our isophote map suggests either a ring seen edge-on, not dissimilar from the OIII ring of 1987A, or some kind of jet-like structure. The symmetric pattern outlined by the Hα image appears to be centred on the northern maximum we have described above. This is shown in Figure 6, where the outer contours of the remnant seen in the OIII, Hα and in V filters have been superimposed to the position of the two maxima.

The northern object is clearly favourite because of its more compact appearance as well as of its central position with respect to the remnant as a whole and to the Hα structure, which seems to originate from it.

A high resolution U exposure of the remnant is required to confirm the proposed optical counterpart of the pulsating source, which is known to be particularly bright in U (Middleditch et al., 1987).

PSR 0540-693 would thus be the third case of an optically identified neutron star, providing a nice example of the capability of the NTT equipped with SUSI.

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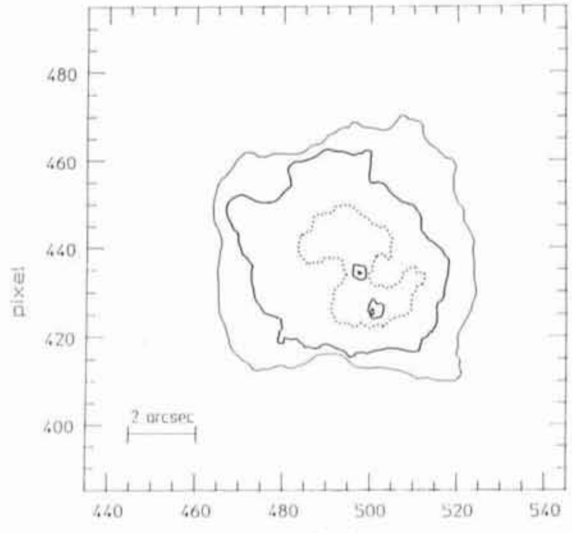

Figure 6: *Superposition of outer contours of the remnant as seen at various wavelengths. Thin line OIII, thick line V, dotted line Hα, the two continuum maxima are also shown.*

DOING RESEARCH WITH SMALL TELESCOPES:

Frequency Analysis of Multiperiodic δ Scuti Stars

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1. A Preliminary Approach to the Problem

δ Scuti variables (hereafter DSCT variables, following the *General Catalogue of Variable Stars* notation) are a numerous class of pulsating stars located in the lower region of the instability strip; they are Pop. I, A–F main-sequence or giant stars and they are now clearly separated from the Pop. II objects, currently named SX Phe stars. The presence of many non-radial modes simultaneously excited in some of these stars renders them very interesting from the point of view of asteroseismology, making possible in principle to resolve their internal structure. Moreover, most of them have very high apparent luminosities and the task of obtaining the needed data can be achieved in a very economic way by using small-size telescopes. In spite of this, Kurtz (1988) emphasized that multimode DSCT pulsators for which a successful frequency analysis is available are very few and restricted to high amplitude cases (AC And, VZ Cnc, 1 Mon, δ Sct, AI Vel) with the only exception of the small amplitude case of θ^2 Tau; his recommendation was "to obtain complete frequency solutions for as many multimode pulsators as possible". The main reason for this difficulty is the complex mixture of radial and non-radial modes often observed in this class of variable stars: we will meet cases for which six periods are not sufficient to solve the light curve. Moreover, the problem of the stability of the mode amplitudes was recently reviewed with the analyses of datasets spanning several observing seasons.

At Merate Observatory, the study of DSCT stars began in the sixties and spectroscopic and photometric campaigns were continuously undertaken in order to clarify the controversial points. As an obvious extension of the research, the observation of DSCT stars was proposed for telescope-time allocation at ESO, in order to take advantage of the ESO facilities and of the considerably better sky of La Silla. After some observing runs devoted to a search for variability in open clusters, we monitored some faint stars with an amplitude greater than 0.4 mag and classified as DSCT stars. The observations, carried out at the ESO 1-m telescope, were planned to increase the sample of stars for which Fourier parameters are available, but they led us to the unpleasant discovery that a lot of the stars classified as DSCT or SXPHE by the GCVS are actually eclipsing variables (see LeBorgne et al., 1989 for the case of CK Aqr). Remarkable exceptions are KU Cen (Poretti et al., 1990) and V974 Oph (Poretti and Antonello, 1988). Fourier decomposition of high-amplitude DSCT stars opened some interesting questions about further subdivision of their photometric features, as for example the existence of a subclass characterized by light curves with a descending branch steeper than the ascending one. Moreover, the multimode nature of V974 Oph became evident only after a second 7-day observing run at the 1-m telescope, but on that occasion we could not obtain a satisfactory solution because of a bad spectral window. Indeed, the light curve of this star is actually much more complicated than that described in the preliminary analysis (Poretti and Antonello, 1988). This case showed us that a multimode pulsation is also present in very large amplitude stars (V974 Oph reaches an amplitude of 0.5 mag in B-light and Figure 1 shows an example of the dramatic changes occurring over a short time baseline) and the collection of larger and longer datasets became a fixed step in the study of all the DSCT stars.

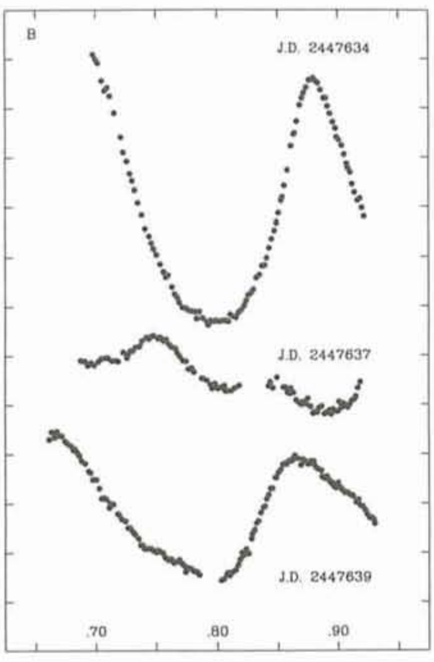

Figure 1: *The light curves of V974 Oph on three close nights: the strong changes in the shape are the largest in amplitude ever observed in a DSCT star. Ticks on the vertical axis are separated by 0.10 mag.*

2. A More Rigorous Approach

All this considered, the study of DSCT stars constitutes a stimulating challenge which requires not only a careful choice of the programme stars, but also the set-up of a powerfull method of frequency analysis, of an error-minimizing observing procedure and the readiness to spend many nights at the telescope.

Table 1: *List of the DSCT stars observed at Merate and ESO. The number of measurements N and the total length of the monitoring are relative to the programme star, while the standard deviation S.D. is relative to its comparison stars.*

Star	Site	Observing period	Nights	N	Survey [hours]	Filter	S.D. [mag]
V356 Aur	Merate	Jan. 1986	6	462	32	B, V	0.0090
HR 1225	ESO	Nov. 1987	7	705	38	b	0.0033
o^1 Eri	ESO	Nov. 1987	7	710	38	b	0.0033
HR 547	ESO	Nov. 1987	8	462	22	b	0.0050
SAO 4710	Merate	Dec. 1988 – Jan. 1989	10	1131	54	B	0.0081
HD 101158	ESO	Apr. 1989	13	1234	62	B	0.0033
V974 Oph	ESO	Apr. 1989	13	1329	64	B	0.0060
X Cae	ESO	Nov. 1989	10	1013	54	V	0.0044
44 Tau	Merate	Dec. 1989 – Feb. 1990	25	2434	117	V	0.0087
BD+2°1867	ESO	Jan. – Feb. 1991	14	1392	100	V	0.0046
BD+2°1867	Merate	Jan. – Feb. 1991	10	708	43	V	0.0094
BD−3°5741	ESO	Sep. – Oct. 1991	20	2649	120	B	0.0044
HD 18878	Merate	Nov. 1991 – Jan. 1992	25	2900	150	V	0.0056

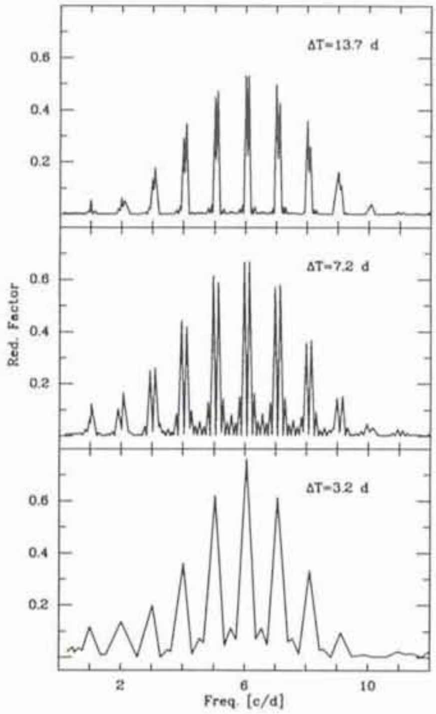

Figure 2: *When dealing with a close doublet of frequencies, an insufficient length of the observing run can lead to an unresolved peak (lower panel) or to wrong identifications (middle panel). The right power spectrum is shown in the upper panel.*

How can the task be tackled? The past schedules indicated that the ESO 50-cm telescope was more suitable than the 1-m telescope for observing runs longer than a week. With respect to the problems described above, the time resolution offered by long observing runs with a very performing instrument such as the ESO 50-cm was an astronomical facility that it would have been silly not to exploit fully.

We therefore put in our observing programme DSCT stars showing cycle-to-cycle variations and, possibly, an amplitude larger than 0.05 mag in order to have a better signal-to-noise ratio. In Table 1 we report the list of DSCT stars observed at Merate and at ESO for which at least a preliminary analysis is available. The measurements were performed in a differential manner, always using two close comparison stars having the same B – V (or b – y) index as the variable: this procedure allows us to minimize the errors introduced by changes in the sky transparency, crucial at the low height above sea level of Merate Observatory, but of some importance also at La Silla. For each variable star, the last column of Table 1 lists the standard deviations observed between the comparison stars. Generally, the measurements obtained in this way are separated by a very short time interval (about 0.002 on the average) and they allow us to reconstruct the light curve in a very faithful way, leaving no ambiguity on the sense of variation or on the reality of small features: this is particularly important in view of the expected complicated light curves. If necessary, uvbyß magnitudes are calculated by observing some standard stars located near the variable star.

A fundamental point is to understand the importance of an adequate resolution in order to perform an accurate frequency analysis. To show it, we generated a synthetic dataset containing a signal which is the sum of two sine-waves with f_1=6.00 c/d and f_2=6.10 c/d, amplitude 0.020 mag and phase difference of 2.0 rad; no noise was added. The signal was sampled in time in the same manner as the measurements of HD 101158 (see Table 2 in Poretti for further details). Then we performed a frequency analysis on the basis of the whole dataset (ΔT=13.7 d), the first 7 nights (ΔT=7.2 d) and the first 4 nights (ΔT=3.2 d). We used either a Fourier Transform method or a least squares method (for a comparison between the two methods, see Antonello et al., 1986): the results were the same and they are shown in Figure 2, where the least squares power spectra form was preferred. In the upper power spectrum the two peaks are separated and the frequencies (i.e. 6.00 c/d and 6.10 c/d) are exactly identified; in the medium panel the two peaks are separated, but the tops occur at 5.96 c/d and 6.14 c/d, i.e. at wrong values; in the lower power spectrum the two peaks are not resolved and instead one large peak centred at 6.04 c/d is visible. Even if these discrepancies could be predicted by evaluating the interaction of the main peak corresponding to one periodicity with the sidelobes related to the other, they are a demonstration of the conspicuous gain in the handling of data that is achieved by increasing the length of an observing run.

3. Observational Results

For some of the stars listed in Table 1, Figure 3 summarizes the identified frequencies with the respective amplitudes. The frequency spectra of HR 1225 and HR 547 display an abrupt decrease between the first two (HR 1225) or three (HR 547) highest amplitudes to the others, while o[1] Eri represents the most unfavourable case where a rather high amplitude value (0.06 mag)

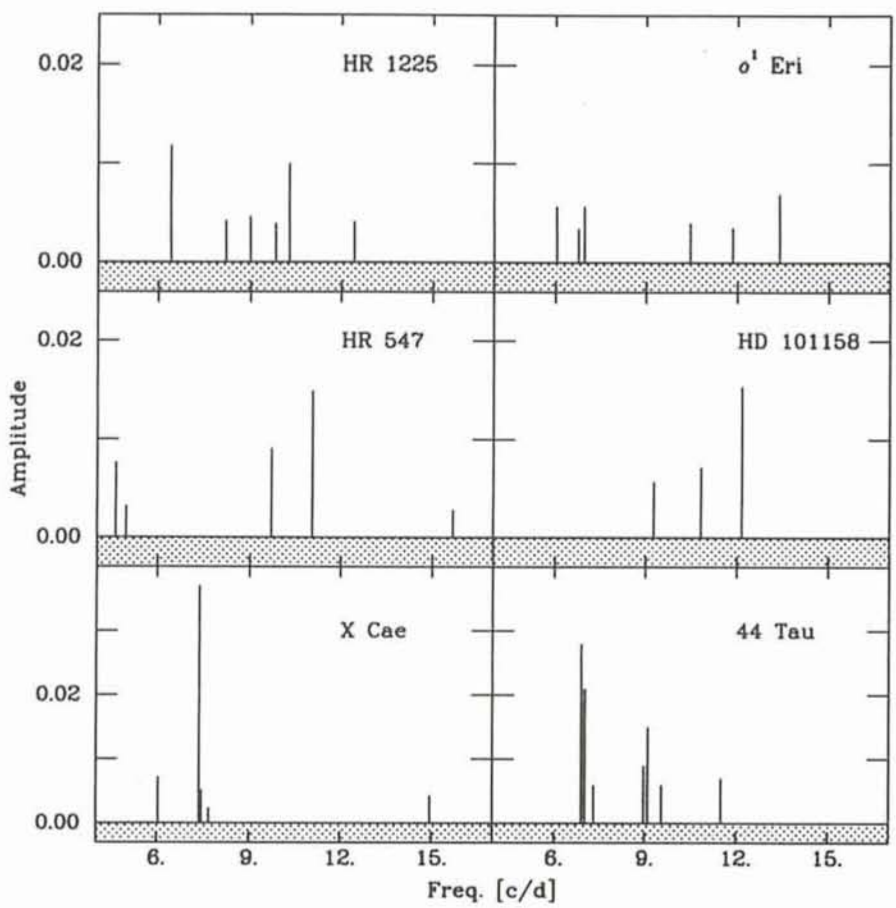

Figure 3: *Graphical description of the frequency identifications in the power spectra of some of the DSCT stars discussed in the text. Note the close doublet frequency near 7.4 c/d in the spectrum of X Cae.*

is the sum of many small-amplitude terms. In all these cases the collected measurements are not sufficient to solve completely the light curve (since at least six frequencies are necessary to reduce the rms residual to the level of the observational error and they cannot be all determined unambiguously), but together with uvbyβ photometry they furnish the possibility to discriminate between radial and non-radial pulsation modes (Poretti, 1989). The amplitude spectrum of X Cae is similar to the previous ones: we observe a single dominant frequency and a group of terms with an amplitude from 5 to 15 times smaller. In spite of this, the high-precision measurements allowed us to evidence non-linear coupling terms and possible resonance effects and a satisfactory solution with 8 sine-waves could be proposed (Mantegazza and Poretti, 1992). The non-linear coupling terms are also evidenced in the frequency spectra of BD+2°1867. Thanks to its equatorial position, this star was also observed at Merate Observatory in a double-site simultaneous campaign which allowed us to reduce the aliases at ± 1 c/d and to perform a more accurate analysis. Figure 4 shows one of the longest strings of measurements: the multimode pulsation nature is evident. These objects are a good example of the difficulties inherent in the frequency analysis of DSCT stars. However, it was always possible to search for periodicities down to very small amplitude values and to give a satisfactory picture of the modal content.

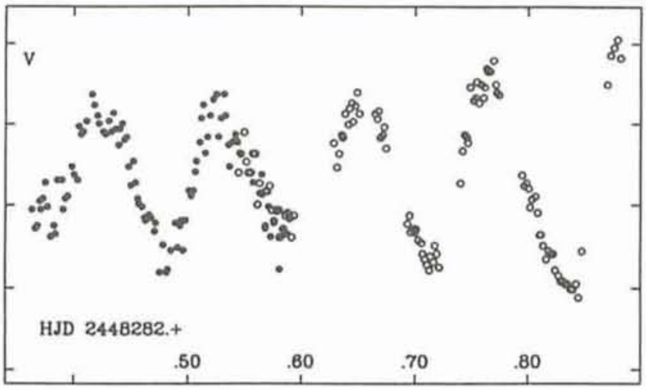

Figure 4: *A light curve of BD + 2°1867. Dots: Merate measurements; open circles: ESO measurements. Ticks on the vertical axis are separated by 0.03 mag.*

Multi-site campaigns are often invoked to solve the most complicated light curves; this is undoubtedly right, but our intensive observations of 44 Tau show that single-site monitorings can be very productive if they take full advantage of the greater availability of telescope time. The light curve solution 44 Tau (Poretti et al., 1992) is important for another reason: if we look at its very rich power spectrum reported in Figure 3, at first sight we can think that it originated from the work of rotational splitting. The presence of the second-order coefficients can destroy the equidistant structure and generate groups of unequally spaced frequencies. 44 Tau is a very slow rotator (v sin i=5 km/s) and our analysis concluded that the seven identified frequencies are independent from each other: we also noted that the two largest amplitude frequencies differ by only 0.11 c/d. Therefore this close doublet and more generally the whole spectrum should be ascribed to physical reasons that are different from rotational splitting.

We must also mention that there are DSCT stars with a much less complicated light curve, such as SAO 4710≡HD 16439, HD 37819 and HD 101158. This type of stars is the most suitable for single-site observations and perhaps for the study of variability in mode amplitudes. The double-mode stars SAO 4710 and HD 37819 were observed at Merate and we note again the presence of a factor of 4–5 between the amplitude of the dominant frequency and the second term. In the light curve of HD 101158 (observed at ESO) three pulsation modes can be identified (Fig. 3). Our solution is different from a previous one reported by Lampens and Rufener (1990), but it fits their measurements satisfactorily. This fact emphasizes the necessity of having light curves with a good coverage at our disposal (as they result from a continuous monitoring during the night described in the previous section) because in this case we can obtain a solution only leaving the uncertainties related to the ± 1 c/d alias problem. The technique of measuring a DSCT star once every 10–15 minutes generates datasets for which many solutions are possible, each giving slightly different rms residuals. From a mathematical point of view, this means that in the least-squares parameter space the objective function has a very smoothed behaviour and many parameter combinations can be picked up with only marginal differences on the goodness of the fit.

4. Implications for the Future

The frequency analysis here summarized can be regarded as pictures of the complicated multimode pulsation of the stars in the lower part of the instability strip. If the variability in mode amplitudes will be confirmed by new observations of other DSCT stars the scenario will be even more complicated. To solve the matter it will be necessary to get well sampled datasets in the future. Therefore, the possibility to do precise photometry with a small telescope on a baseline of 10–15 nights can establish some experimental evidences in agreement with the theoretical requests, as testified by our activity.

For these reasons we look at the ESO policy in the near future with great worry. Even in the case where the "streamlining" of La Silla would not involve a reduction of the efficiency of the ESO facilities, we are not able to find a scientific justification to the strong reduction in the ESO photo-electric instrumentation (after 1996 only the 1-m telescope will be equipped part-time with a photometer; Cristiani 1991). In our opinion, the possibility to obtain a high time-resolution is a requirement in many research fields and it is a facility which should be maintained at the disposal of the scientific community since it is based on the same attitude as the one that, for example, drives technologists to plan sophisticated instruments to improve spatial resolution of data analysts to develop software packages to better extract the signal from the noise.

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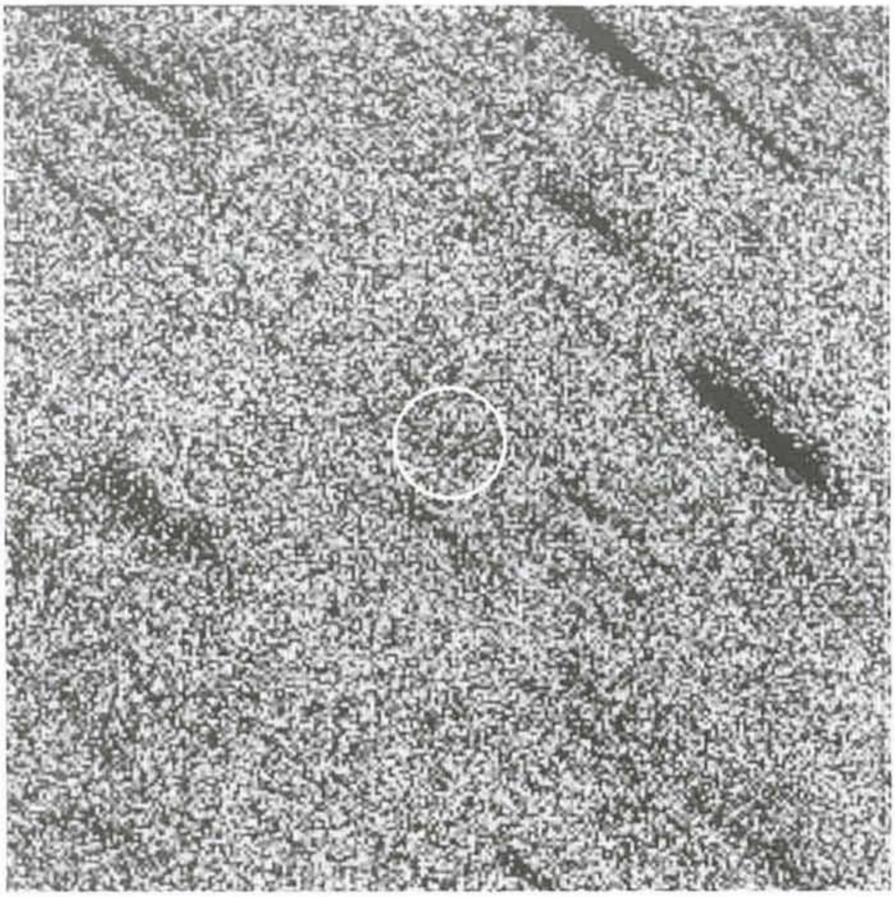
Halley Back to Normal

O. HAINAUT, A. SMETTE and R.M. WEST, ESO

This photo shows a small sky area in the direction of Comet Halley, obtained with the ESO 3.5-metre New Technology Telescope (NTT) in the morning of April 6, 1992.

It is a composite of 10 individual exposures in the standard V-band, obtained between UT 2:33 and 4:58 with a total integration time of 130 minutes. They were combined in such a way that the image of the moving comet remains at the same position and the stars are therefore seen as trails. The position of Comet Halley is at the centre of the circle and is located only 2 arcmin north-west of a magnitude-7 galactic star. Its strong light introduced a very skew background illumination which was removed by fitting a 3rd-degree and subtracting.

At the time of the observations, Comet Halley was 15.67 AU (2343 million km) from the Earth and 16.22 AU (2424 million km) from the Sun. The predicted mean magnitude of the nucleus alone is V = 25.95, with variations from about 25.5 to 26.5 due to the rotation. A careful analysis indicates that there may be a very faint image near the limit of the combined frame at the predicted position, and with magnitude $V = 25.8 \pm 0.4$. However, it is hardly visible and this value must rather be considered an upper limit of the present brightness of the comet. But in any case, the magnitude cannot be much brighter than what is expected from the nucleus alone.



This observation therefore shows that the large dust cloud which was ejected during a dramatic eruption in late December 1990 and first observed at La Silla in mid-February 1991, has now effectively disappeared. At the present time, 16 1/2 months after the 19-mag outburst, there is very little, if any dust left near the nucleus.

The ESO observations of comet Halley will continue.

The photo covers an area of 85×85 arcseconds; north is up and east is to the right.

Spectroscopic Observations in the Cluster of Galaxies Abell 151

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Introduction

Redshift surveys in clusters of galaxies are needed to study their dynamical and evolutionary states, estimating parameters such as the mass, shape and distortion of the velocity field, presence of substructures or projected galaxies and groups, strength of dynamical friction and two-body processes and, in general, the present stage of their dynamical evolution. This information is useful not only to test scenarios of galaxy formation, but also of the formation and evolution of large structures.

In clusters, the mean velocity is a key factor in deriving distances, permitting the study of matter distribution over very large scales. Within clusters the analysis of the velocity field can lead to an estimate of the virial mass, constraining models of the dark matter content. Galaxy velocity measurements provide information complementary to that obtained through X-ray observations of clusters. Both form basic pieces of information for the understanding of clusters. However, reliable parameters are derived from analysis of large samples of velocities. These are laborious to obtain, a task made more efficient by the

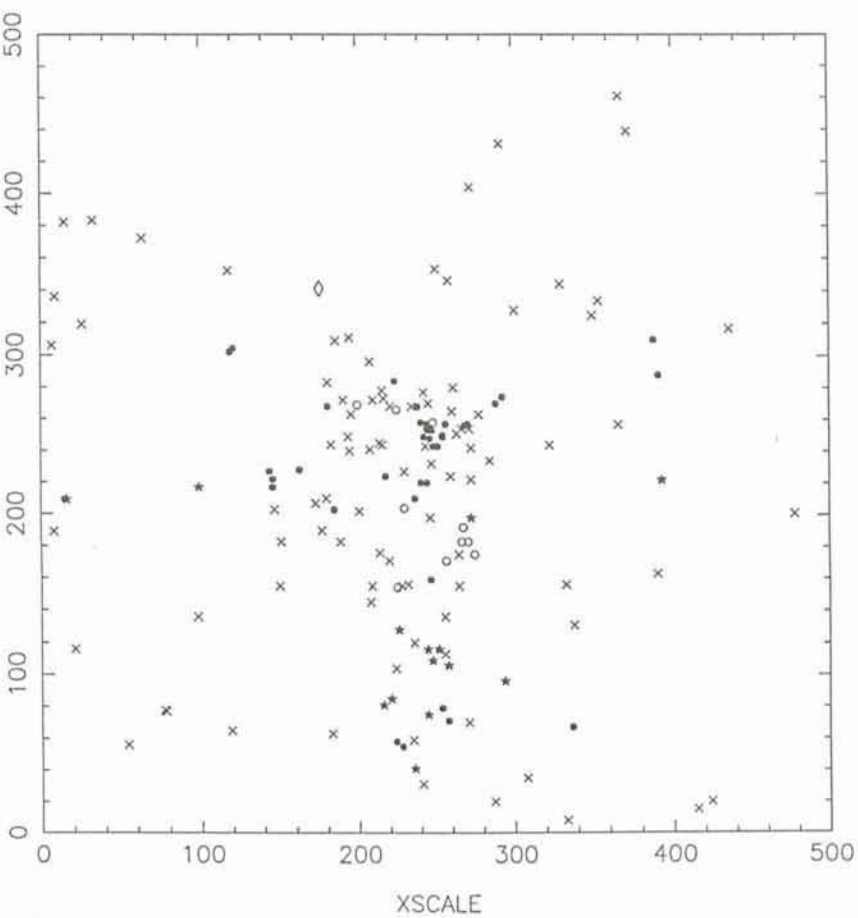

Figure 1.

wider use of multiobject spectroscopy. Here we study the velocity and galaxy distribution in the cluster A 151 which is a richness 1 one and a cDs RS-type for which 105 objects have been listed in Dressler's catalogue (1980).

Observations and Data Reductions

The programme of radial velocity measurements was carried out in December 1985 at the ESO 3.6-m telescope and in October 1990 at the ESO 1.52-m. We used the multiobject spectrograph OPTOPUS in its "old" configuration at the 3.6-m Cassegrain focus equipped with 35 separate optical fibers for collecting the ligth from galaxies spread over a field of 33 arcminutes diameter in the telescope focal plane. With the use of the F/1.9 dioptric spectrograph camera, each fiber output was projected onto an RCA CCD (512 × 320 pixel) detector with a fiber image size of 85 μm (2.8 pixels). A dispersion of 114 Å/mm was used, providing spectral coverage from 3800 to 5570 Å. The preparation of the drilled OPTOPUS plates was made by measuring positions of galaxies on the glass copy of the Palomar Sky Survey with the OPTRONICS machine at ESO-Garching, with respect to 20 reference SAO stars.

Observations with the 1.52-m telescope were carried out in October 1990. We used the Boller and Chivens spectrograph at the Cassegrain focus, equipped with the 600 lines/mm grating blazed at 5000 Å and coupled to an RCA CCD (1024 × 640 pixels) detector with pixel size of 15 μm. A dispersion of 129 Å/mm was used, providing spectral coverage from 3750 to 5700 Å.

The data reduction of the OPTOPUS data was carried out using the IRAF package, while the 1.52-m one was reduced at Garching using IHAP. The radial velocities were derived from the cross-correlation procedure developed at Meudon in the eVe software. Wavelength calibration was performed using the He-Ar lamp reference.

Results

With previous measurements in the same cluster (Proust et al. 1988), and few other data from literature, we obtain for A151 a total of 65 velocities. Ten galaxies with velocities greater than 20,000 km s^{-1} are background objects. During the preparation of the OPTOPUS observations, 158 galaxies were selected after inspection on the Palomar glass plates, considering suitable magnitudes in the central 40′ diameter field, approximately. Figure 1 shows all the galaxy positions symbolized with a circle for objects with $V_r > 20{,}000$ km s^{-1}, filled dot with $14{,}000 \leq V_r < 20{,}000$ km s^{-1}, and filled star with $10{,}000 \leq V_r < 14{,}000$ km s^{-1}. Non-measured objects are represented with a cross; A very

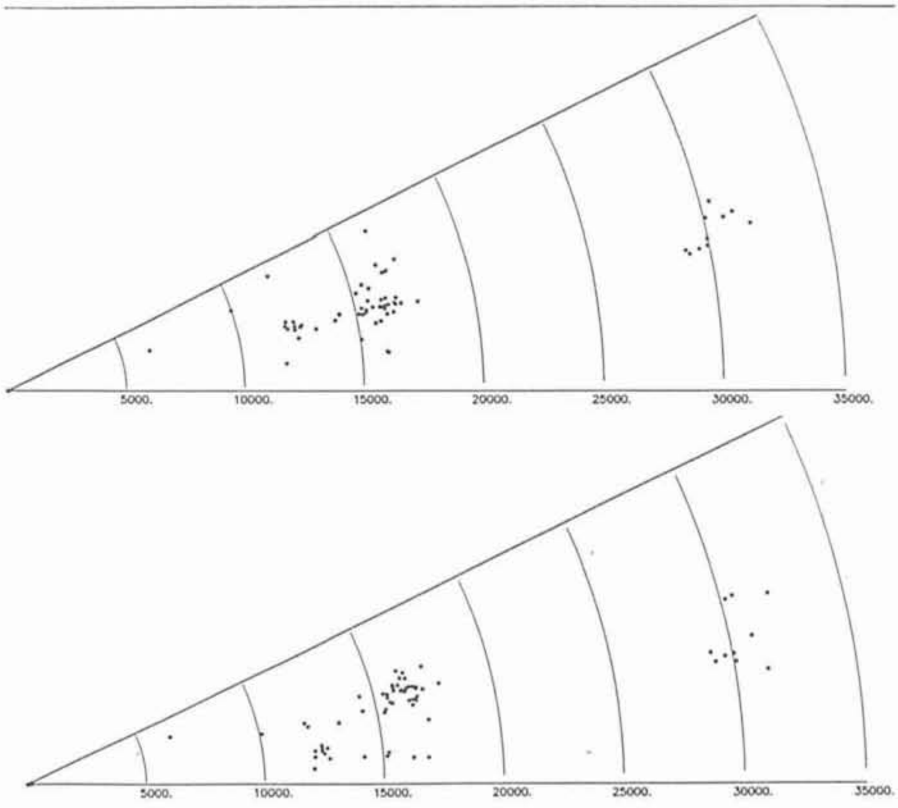

Figure 2.

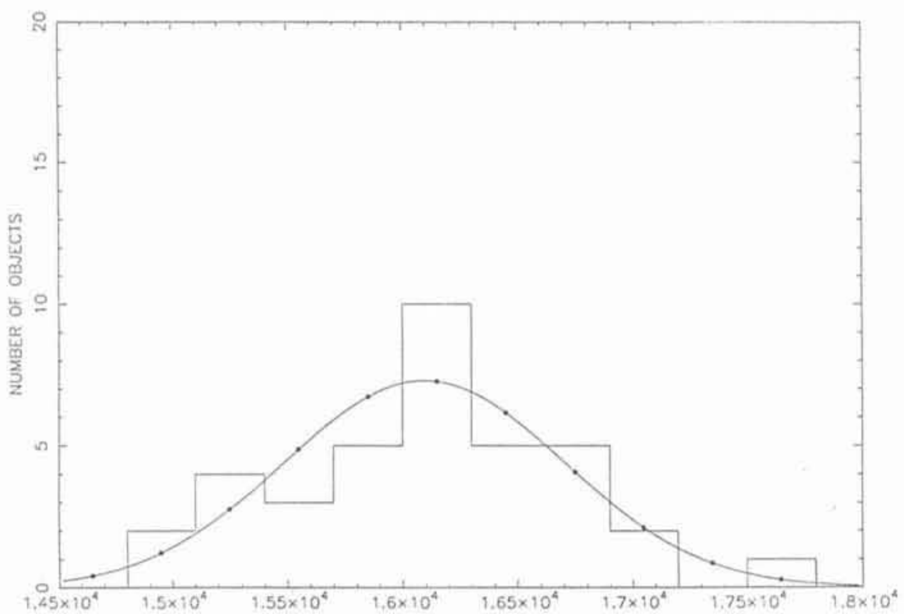

Figure 3.

foreground galaxy is symbolized with a diamond.

Figure 2 shows the velocity wedge diagrams in right ascension, and declination. From Figures 1 and 2 one can see the presence of a foreground structure in the southern region. Considering that in the 30 arcmin. central region the sampling is fairly homogeneous, we can estimate that the central D galaxy is located 5.2 arcmin. from the main cluster centre.

Figure 3 shows the histogram of radial velocities for the main cluster with a fitted Gaussian centred at the mean velocity $\bar{V} = 16090 \pm 94$ km s^{-1} with a corrected velocity dispersion $\sigma = 587^{+85}_{-61}$ km s^{-1}. From the standard Friedman cosmology (Mattig 1958) with:

$$D = \frac{c}{H_0 q^2_0 (1+z)} \left(q_0 z + (q_0 - 1)[\sqrt{2q_0 z + 1} - 1]\right)$$

we obtain a mean cluster distance of 148 Mpc assuming H_o = 100 km s^{-1} Mpc^{-1} and q_o = 0.1 and an Abell radius of 35 arcmin. (1.51 Mpc); the foreground structure has a mean distance of 115 Mpc.

The dynamical mass estimations are tabulated below for the main cluster and for the foreground substructure:

Dynamical Mass Estimation	Main Cluster (10^{14} $M_\odot$)	Substructure (10^{14} $M_\odot$)
Virial Mass	2.05	0.28
Projected Mass	5.44	0.36
Average Mass	4.43	0.28
Median Mass	3.15	0.40

In order to check if the substructure is bound to the main body of the cluster, we have used the procedure which assumes radial orbits. The newtonian criterion for gravitational binding can be stated in terms of the observables as:

$$\frac{V_r^2 R_p}{2GM} \leq \sin^2\alpha \cos\alpha$$

where V_r is the relative velocity along the line of sight of the cluster and its substructure, R_p the projected separation between the cluster and the substructure, M the total mass (cluster + substructure) and α the angle between the cluster and the substructure with the plane of the sky. A necessary condition for bound solutions is that the left quantity in the above equation must be less than 1. Our computations lead to the conclusion that the substructure is not bound to the main cluster. Therefore, it is a projected foreground cluster.

The velocity data show 3 structures, the main cluster at z = 0.0537, a foreground group at z = 0.041 and a background population at z = 0.1. The nearest cluster with known z close to A 151 is A 133 (z = 0.0604). No close companions at the same z are apparent within 5 degree of A 151. However, the background galaxies have similar z as A 166 at z = 0.11. Moreover, the 4 clusters A 131, A 148, A 157 and A 159 have similar distance class = 5 and similar Abell radii Ra_o = 0.28 within 2 degrees of the centre of A 151. It seems likely that the background grouping belongs to a supercluster at z = 0.11–0.12. Within 6 degrees, there are three other clusters in this redshift range; Figure 4 shows the positions of the nearest clusters on the sky.

We thank the ESO staff, and especially Olivier Hainaut, Pierre Leisy, Pascal Fouqué, Mohammad Heydari and Daniel Hofstadt; Johann Sebastian Bach music provided by Bo Reipurth was greatly appreciated during the observing runs.

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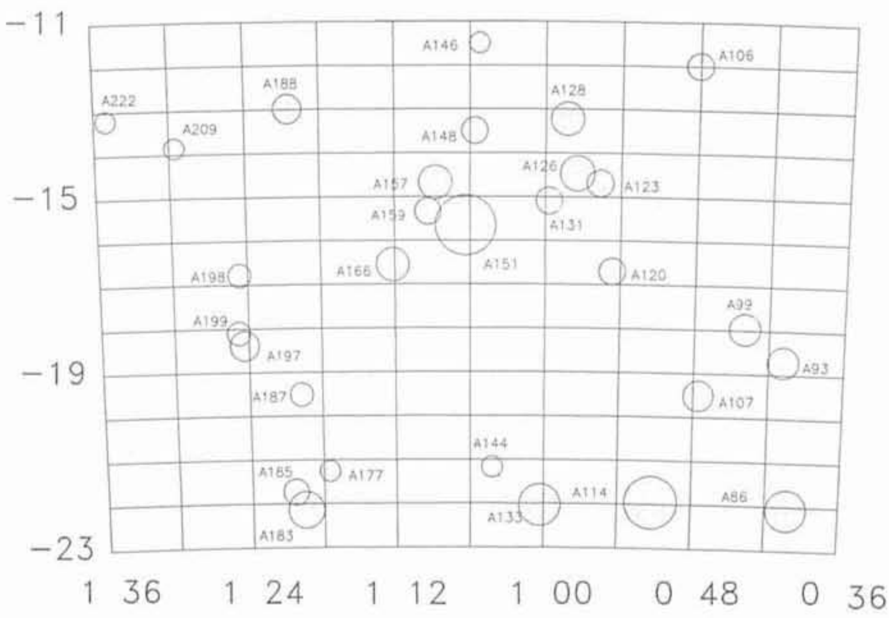

Figure 4.

Russian Rockets and American Comets

Last Messenger *issue featured different types of objects in the sky over La Silla and other observatories, including two sightings of "strange" phenomena, one supposed to be connected to a Russian rocket and the other of unknown nature (*Messenger ***67***, page 56–58).*

It is always a special pleasure for an editor to learn that the journal he works on is read by other people! This was certainly the case in connection with the mentioned articles, and quite a few commentaries were received. The fact that many Messenger *articles with scientifically much more "valuable" content remain without such reactions may have something to do with human nature and the attitude towards the unknown...*

Like a good detective story, the solution of the mystery comes at the end, in this case on the following pages. It was indeed a Russian rocket, but who would have guessed the true nature of the second object?

I am most thankful to Drs. Böhnhardt, Ferrin, Johnson and Rast, for having contributed to the de-mystification of these events. Each of the following four articles cast their own light on them.

It also appears that these (and other similar) cases have now led Richard Rast to seriously consider the establishment of a non-profit "Center for Analysis of Satellite Interference with Astronomy (CASIA)". As former Chief of the Orbital Analysis Division at NORAD in Colorado and later at NASA's Johnson Space Center in Texas, he is in an excellent position to judge what such a Center could do for astronomers. The a-posteriori identification of satellite trails on photographic plates and in CCD frames may be of little consolation for the unhappy observers, but the day might be near when particularly critical observations will benefit from a-priori knowledge of the sighting directions of the roughly 30,000 artificial objects in known orbits. In such cases, it may become possible to predict exactly when the shutter can be opened without risk of discovering a dense trail on top of the object of interest, at the end of the exposure several hours later. And dramatic events experienced by the public like the ones described here, could quickly be explained in the correct way, if the information were passed on in real time. This would undoubtedly have an important educational value.

Further information about the CASIA project may be obtained from:

Richard H. Rast, 18411 Anne Drive, Houston, Texas 77058-3203, USA, Telephone 713-333-2830. The Editor

New ESO Preprints

(March – May 1992)

Scientific Preprints

824. M. Olberg, Bo Reipurth and R.S. Booth: A Molecular Outflow Associated with Herbig-Haro Jet HH 46/47. *Astronomy and Astrophysics.*
825. E. Palazzi, N. Mandolesi and Ph. Crane: CN Rotational Excitation. *Astrophysical Journal.*
826. M. Della Valle: Nova Rate in M 33 and in the Galaxy. Invited paper presented at the Workshop on "Cataclysmic Variable Stars", July 15–19, 1991, Viña del Mar, Chile.
827. 1. F. Murtagh: A New Approach to Point Pattern Matching. *Publications of the Astronomical Society of the Pacific.*
2. F. Murtagh: Multivariate Analysis and Classification of Large Astronomical Databases (followed by discussion). *Statistical Challenges in Modern Astronomy*, G.J. Babu and E.D. Feigelson (Eds.), Springer-Verlag, New York.
3. F. Murtagh: Contiguity-Constrained Clustering for Image Analysis. *Pattern Recognition Letters.*
4. F. Murtagh: Cosmic Ray Discrimination on HST WF/PC Images: Object Recognition-By-Example. First Annual Conference on Astronomical Data Analysis Software and Systems. J. Barnes, C. Biemesderfer and D. Worrall (Eds.), Astronomical Society of the Pacific.
828. P. Padovani: Is there a Relationship Between BL Lacertae Objects and Flat Spectrum Radio Quasars? *M.N.R.A.S.*
829. M. Della Valle and J. Melnick: The Distance to NGC 5253 and the Absolute Magnitude at Maximum of SN 1972 E. *Astronomy and Astrophysics Letters.*
830. G. Mathys: The Inhomogeneous Distribution of Oxygen on the Surface of the Magnetic Ap Star HD 125248.
831. S.M. Viegas and M. A. Prieto: Probing Photoionization Models in Two Well Studied Extended Emission-Line Regions: Cen A and 3C 227. M.N.R.A.S.
832. A. Jorissen and H.M.J. Boffin: Evidences for Interaction Among Wide Binary Systems: To Ba or Not To Ba? To appear in "Binaries as Tracers of Stellar Formation", Eds. A. Duquennoy and M. Mayor, Cambridge University Press, 1992.
833. B. Barbuy et al.: Light Element Abundances in Barium Stars. *Astronomy and Astrophysics.*
834. H. Van Winckel, J.S. Mathis, C. Waelkens: Unusual Chemical Abundances in Some Peculiar Stars Due to Fractionation. *Nature.*
835. D.G. Yakovlev et al.: Photoionization Cross Sections of Atoms and Ions from He to Zn. *Astronomy and Astrophysics.*
836. E.D. Feigelson and F. Murtagh: Public Software for the Astronomer: An Overview. *Publications of the Astronomical Society of the Pacific.*
837. A. Moneti, I. Glass and A. Moorwood: Infrared Imaging of IRAS Sources Near the Galactic Centre. *M.N.R.A.S.*
838. R. Pallavicini, L. Pasquini and S. Randich: Optical Spectroscopy of Post-T Tauri Star Candidates. Astronomy and Astrophysics.
839. R. Liseau et al.: Star Formation in the Vela Molecular Clouds: I. The IRAS-Bright Class I Sources. *Astronomy and Astrophysics.*
840. F. Matteucci and P. François: Oxygen Abundances in Halo Stars as Tests of Galaxy Formation. *Astronomy and Astrophysics Letters.*
841. J. Einasto, M. Gramann and E. Tago: Power Spectrum of the Matter Distribution in the Universe on Large Scales.
842. T. Theuns: Hydrodynamics of Encounters and Molecular Clouds. I. Code Validation and Preliminary Results. II. Limits on Cluster Lifetimes. *Astronomy and Astrophysics.*
843. L.B. Lucy: Resolution Limits for Deconvolved Images. *Astronomical Journal.*
L.B. Lucy: Statistical Limits to Superresolution. *Astronomy and Astrophysics.*

Technical Preprints

43. M. Faucherre: Summary of the session on Methods for Optical Pathlengths Compensation. To be published in the Proc. of ESO Conf. on "High Resolution Imaging by Interferometry", Garching, Oct. 14–18, 1991.
44. A. Wallander. Remote Control of the ESO new Technology Telescope. Paper presented at the Workshop on "Remote Observing", held in Tucson, USA, April 21–23, 1992.
45. O. von der Lühe: Ground-Based High Angular Resolution Observation of the Sun by Interferometry in the Visible. Paper presented at the ESA Workshop "Solar Physics and Astrophysics at Interferometric Resolution", ESA HQ, Paris, 17–19 February 1992.
O. von der Lühe et al.: Interferometry with the Very Large Telescope. Invited paper at ESA Workshop "Solar Physics and Astrophysics at Interferometric Resolution", ESA HQ, Paris, 17–19 February 1992.

Close Encounters with Ice Balls of a Second Kind

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The excellent photograph of a possible near miss object *Messenger* **67**, p. 57) allows confident identification. Although Smette and Hainaut mention no colour for the bright, diffuse object, a lithium or barium release would have been noticeably red or green, respectively. The authors consider and then reject such an explanation. They also suggest a re-entering satellite, but the trains sometimes left by these phenomena rarely, if ever, appear circular.

Smette and Hainaut mention that the object was about 15 deg above the horizon, but while appearing to pass above Mars, it was really at only 9 deg elevation. This accurately known position in the sky suggested correlating a pass of some outgassing artificial Earth satellite with the path of the unknown object.

From the available orbital elements of almost 7000 satellites in orbit on January 26, I computed a trajectory for each near 9:05 UTC. Only one matched.

The authors did observe an ice ball, but it was not a cometary nucleus. Space Shuttle Discovery's crew, with German astronaut Ulf Merbold aboard, had just completed a 25-litre Spacelab waste water dump at 8:58 as the orbiter was headed toward South America from over the South Pacific Ocean. The bright condensation of magnitude approximately 1 was not the orbiter itself, since Discovery would have appeared to move at three times the angular speed of the condensation. Instead, the 2-deg-wide, circular nebulosity, backlit at a solar phase angle of 157 deg, was ice crystals which formed as the dumped water – condensed from the crew's respiration and perspiration – froze in space and then slowed due to high drag. The deceleration is directly proportional to cross-sectional area and inversely proportional to mass. Since discrete ice crystals have a much larger area-to-mass ratio than the Shuttle, these individual "satellites" experience a considerable orbit perturbation from the tenuous atmosphere at this altitude. Note also in the photograph accompanying the *Messenger* article how the angular diameter of the bright condensation increases from right to left as it expands, despite actually receding from the camera.

Spacelab's waste water is typically dumped only once per week-long mission. Even the most conservative estimates predict that such an ice ball cannot survive in sunlight without subliming or even remain in orbit for more than a few hours.

Thus, although Smette and Hainaut did not experience some close encounter with a visitor from the outer solar system, they can at least feel privileged to have witnessed a rare and fascinating *artificial comet!*

On the Nature of the Smette-Hainaut Object

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1. The Observations

In the *Messenger*, No. **67**, Smette and Hainaut report their observation of a difuse comet-like object of visual angular diameter around 2 degrees, moving 1.1 degrees per 10 seconds of time, in a northernly direction, at dawn (from now on referred to as S-H's Object).

Using the published picture, I measured a photographic diameter of 0.2 degrees. Let us take this value as a lower limit for the angular diameter, and the former value as an upper limit.

In this work I will explore if the above observations are consistent with what we actually know about comets.

If this were a comet, it would be of the greatest importance to calculate its size and orbit, since the object could belong to the group of pygmy comets postulated by Frank et al. (1986).

2. Distance to the Object

We can obtain the distance to a comet, Δ, from its observed angular diameter, ø, using Figure 1, which shows the linear diameter, D, of the coma of many comets compiled by Wurm (1939), fitted with a law:

(1) $D\ [\text{kms}] = 2.4 \times 10^5 \times R^2$

where R = Distance Comet-Sun. Since S-H's Object was near the Earth, R = 1.0 AU, and $D = 2.4 \times 10^5$, if this object was a comet. Then from

(2) $\text{tg}\ ø = D/\Delta$

we obtain $\Delta = 6.9 \times 10^6$ kms if the diameter was 2 degrees, and 6.9×10^7 if the diameter was 0.2 degrees.

3. Escape Velocity

Using this distance, its linear velocity can then be calculated:

(3) $v = w \cdot \Delta$

where w is the angular velocity in the sky. Using w = 1 degree / 10 seconds of time, we find $v = 1.2 \times 10^4$ kms/sec! And 10 times more if the angular diameter is 0.2 degrees. The maximum relative orbital velocity of a parabolic comet and the Earth is about 71.8 = (29.8+42.0) kms/sec. Thus the above velocities are much too large! The comet would have had a very hyperbolic orbit. No comet with such a hyperbolic orbit has been discovered up to now.

This result means that if the object was a comet, then its diameter was 170 times too small for its speed. Or, its speed was 170 times too large for its diameter. In any case we have a discrepancy by a large factor.

4. Comparison with Comet Iras-Araki-Alcock 1983d.

Comet Iras-Araki-Alcock 1983d, was the closest approach of any comet to Earth since 1770 (when that of Comet Lexell took place), and thus it can be used as convenient comparison. On May 11, 1983, it reached an angular diameter of 3.5 degrees in the sky, at a minimum distance to the Earth of Δ = 0.031 AU (Green, 1983).

Its trajectory was very similar to that of S-H's Object, since it was moving in a N-S direction, almost perpendicular to the ecliptic.

Using the above information we obtain $D = 2.8 \times 10^5$ kms for Comet IAA. This value is plotted in Figure 1 as a square. It lies right on top of the calibration by Wurm (1939). Thus this Earth-approacher serves as a good test of our hypothesis.

The motion of IAA was then of the order of 2 degrees per hour. Object S-H was moving at 2 degrees per 20 seconds of time. This is a factor of 180 larger, which could be accommodated if the object were roughly 180 times nearer. But then its size would have been roughly 180 times larger than IAA, in which case it should have covered the whole sphere, and not 2 degrees as seen.

If it were 180 times nearer than Comet IAA, its distance would be 2.6×10^4, a value smaller than the coma size by a factor of 10! Thus we would be submerged in the comet's coma, and there would be a glow over the whole sky! The photograph would look like a very diffuse central condensation, trailing over the sky, and not as sharp as shown in the published image.

In other words, we get the same discrepancy. Speed and diameter are inconsistent if the object was a comet.

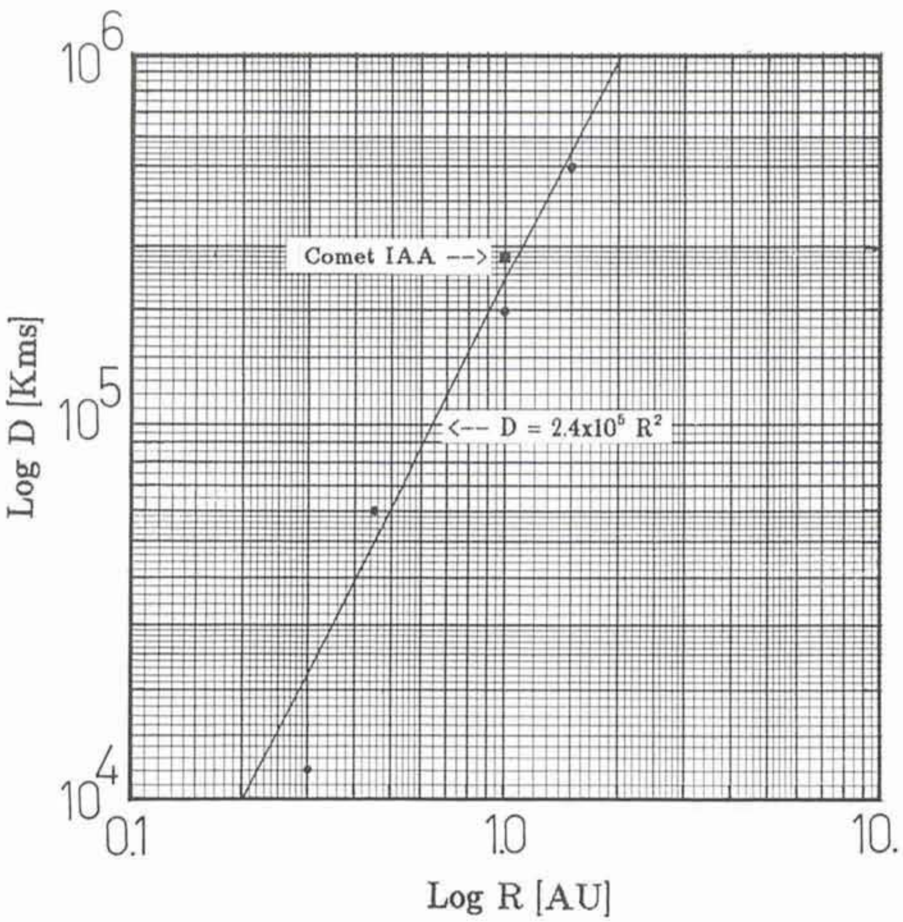

Figure 1: *Diameter of cometary coma as a function of distance to Sun (Wurm, 1939).*

5. Other Hypotheses

The object could be the remains of the exhaust of a Soviet rocket. Several cases have been known of the 3rd stage of a Soviet rocket separating over Chile, producing spectacular clouds of geometric forms (Noel, 1985; Morales, 1989).

The object could have been a "round cloud" or a "round haze". When the atmosphere is very stable, or in laminar flow, as it frequently happens in Chile, it can support round clouds, or round hazes, a spherically symmetric region of saturated water vapour. They do not last for long, but look remarkably as comets. They are even transparent, since bright stars can be seen through them.

I have seen two of them, one of about 1–2 degrees in diameter. The other one was of 5 degrees of diameter. I remember it distinctly because it was located on top of comet Halley, with the rest of the sky completely clear (a good example of the way nature sometimes behaves)! It lasted for about 15 minutes and then went away. If such a round cloud is located at 10 kms from the observer, at dawn, it may look remarkably as a comet. Its speed can be calculated from Equation 3, and comes out to be 60 kms/h depending if the diameter is 2 degrees or 0.2 degrees. This is compatible with the surface winds on Earth.

Thus this hypothesis can be tested. If S-H's Object was a cloud in the Earth's atmosphere; then the wind should have been moving toward the N, at between 6–60 kms/h. This information should be available in the meteorological office. Notice that this assumes that the surface wind is the same as the wind at the object's altitude, which might not be the case.

Additional information could be gained from a study of the image structure in the published picture. If the object was a comet the image structure should show a trailing central condensation, decaying slowly in brightness outward. This does not seem to be the case from a cursory analysis of the image. However a more detailed study is required.

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Unidentified Object Over Chile Identified

The unidentified flying object (UFO) seen from Chile between 2:15 and 2:21 UT on January 24 (*The Messenger* **67**, p. 56) was correctly assessed by author Hainaut as the upper stage of a rocket. However, it was not re-entering, but "exiting" to a higher orbit.

An hour earlier, the Commonwealth of Independent States (CIS) had launched Cosmos 2176 on a three-stage rocket from Plesetsk (2300 km northwest of Baikonur). Typically, the strap-ons and stage zero impact within CIS borders. The first stage places the payload and second stage into a transfer orbit of roughly 200 by 600 km. After separation, the first stage remains in the transfer orbit and the second stage fires while heading north-east off the west coast of South America, before completing one revolution of the Earth.

Until now there was speculation whether this type of UFO seen by Chileans was the first stage venting unburned fuel or the second stage firing. The fine photographs and description provided by La Silla astronomers indicate that, at least in this case, the latter explanation is correct. A nominal second stage burn lasts a little under 4 minutes. Ironically, although its launch was detected visually by astronomers, the mission of Cosmos 2176 is to detect the launch of missiles towards the CIS in the infrared!

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On the "Unidentified Object Over Chile"

In a recent article (*The Messenger* **67**, p. 56–57), O. Hainaut proposes a re-entering satellite or rocket as explanation for the observations of the unidentified object over La Silla on 24.1.92 at 2.15 to 2.21 UT.

A preliminary analysis of the information on satellite launches and decays for the period 23./24.1.92 was performed by H. Köhnke, Satellite Station Stade, and myself in order to confirm or disprove this hypothesis.

Satellite decays*: according to information published in *Spacewarn Bulletin*, the following satellites decayed on 23./24.1.92:

Object	Description	Decay
1986-19-CX	Part of Ariane Launcher	23.1.92
1991-51-A	Microsat 1	23.1.92
1991-51-B	Microsat 2	23.1.92
1991-51-D	Microsat 4	23.1.92
1991-51-G	Microsat 7	23.1.92
1991-51-C	Microsat 3	24.1.92
1991-51-E	Microsat 5	24.1.92
1992-1-B	Rocket Cosmos 2175	24.1.92

Orbit calculations of the Microsats and of Rocket Cosmos 2175 show that none of these objects can be considered a potential candidate to explain the observations of the unidentified object over Chile. For the Ariane launcher part, no orbital elements were available for our calculations.

Satellite launches: according to the RAE tables of Earth Satellites the only launch of interest for the UFO observations is that of Cosmos 2176 on 24.1.92 at 1.12 UT. The orbit inclination of this launch was about 63 deg which points towards the Plesetsk Space Centre (near Archangelsk) as launch site. With this assumption an observability over Chile resulted on 24.1.92 between 2.15 to 2.20 UT for re-entering parts of the Cosmos 2176 launch. The scenario of the re-entry of a rocket launched from the Baikonur Space Centre as proposed by O. Hainaut can be ruled out for two reasons: no parts from the Cosmos 2176 launch would pass over La Silla during the first orbit revolution when launched from Baikonur and most Russian high-inclination launches (i.e. those above 60 deg) are made from Plesetsk.

In summary: The UFO observed on 24.1.92 2.15–2.21 UT over La Silla could have been a part from the Cosmos 2176 launch. However, further investigations are needed to verify this explanation (launch site of Cosmos 2176). In this context, a more detailed description of the UFO trajectory over La Silla or other places in Chile would be very helpful for a positive identification of the Cosmos 2176 launch as origin for the UFO. The decay of a space debris (like 1986-19-CX or others not given in the NORAD catalogues) cannot be ruled out as possible explanation.

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* The decay and orbit information was kindly provided by ESOC Darmstadt.

First Images with IRAC2

ESO's new infrared camera equipped with a 256×256 Rockwell NICMOS 3 array (see *The Messenger*, **67**, 21) was tested on the 2.2-m telescope for the first time during the second half of May. Although the weather was generally poor, a large number of images of a variety of objects were nevertheless obtained and are now being reduced to assess the performance achievable in the various modes. Amongst the first of these are the accompanying images of the A1689 galaxy cluster at z=0.2 and the supernova remnant RCW 103. It is planned to include a more detailed report in the next issue of the *Messenger*.

A. MOORWOOD, G. FINGER, P. BIEREICHEL, H. GEMPERLEIN, J.-L. LIZON, M. MEYER, A. MONETI, ESO

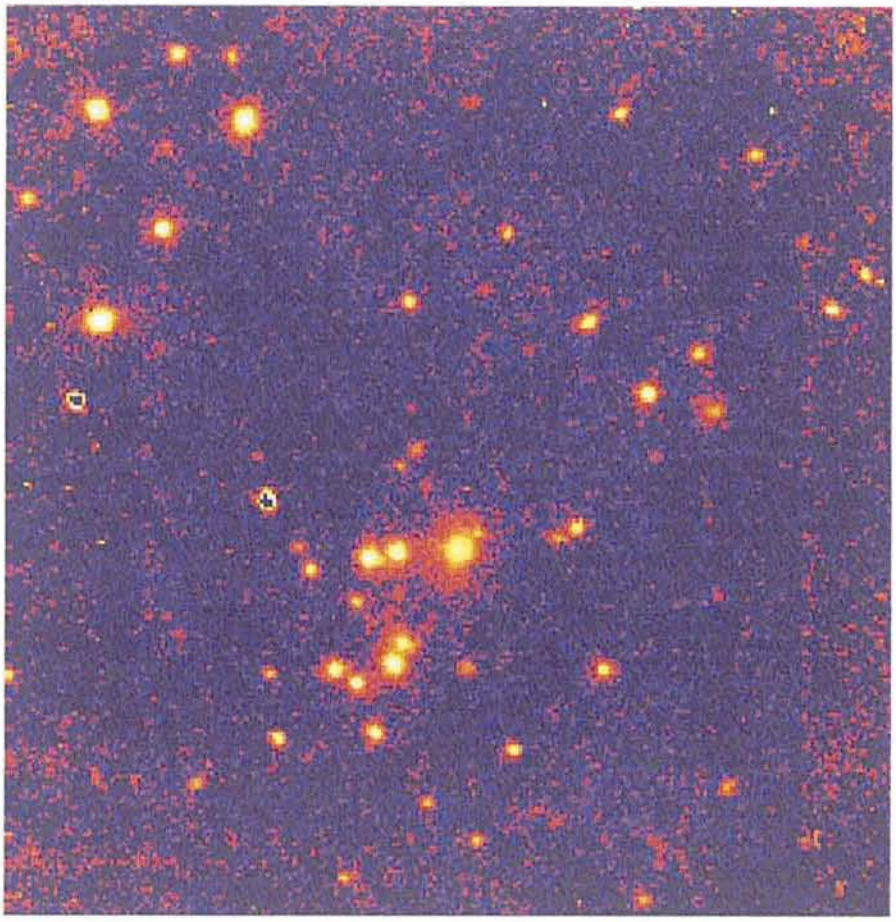

Figure 1: *K' (2.1 μm) image of the galaxy cluster A1689 (z=0.2) obtained with IRAC2 at the 2.2-m telescope on La Silla. The scale is 0.49"/pixel and the field is ~2×2' with N at the top and E to the left. This image was constructed from ten 2-minute exposures made at different positions shifted by ~15" on the sky to enable accurate sky subtraction and removal of bad pixels and has been flat fielded using measurements of the illuminated diffusing screen in the dome. The galaxies have integrated magnitudes in the range K' = 13.5–19 and the r.m.s. noise corresponds to ~21 mag (arcsec)^2. (Image processing: Reynier Peletier).*

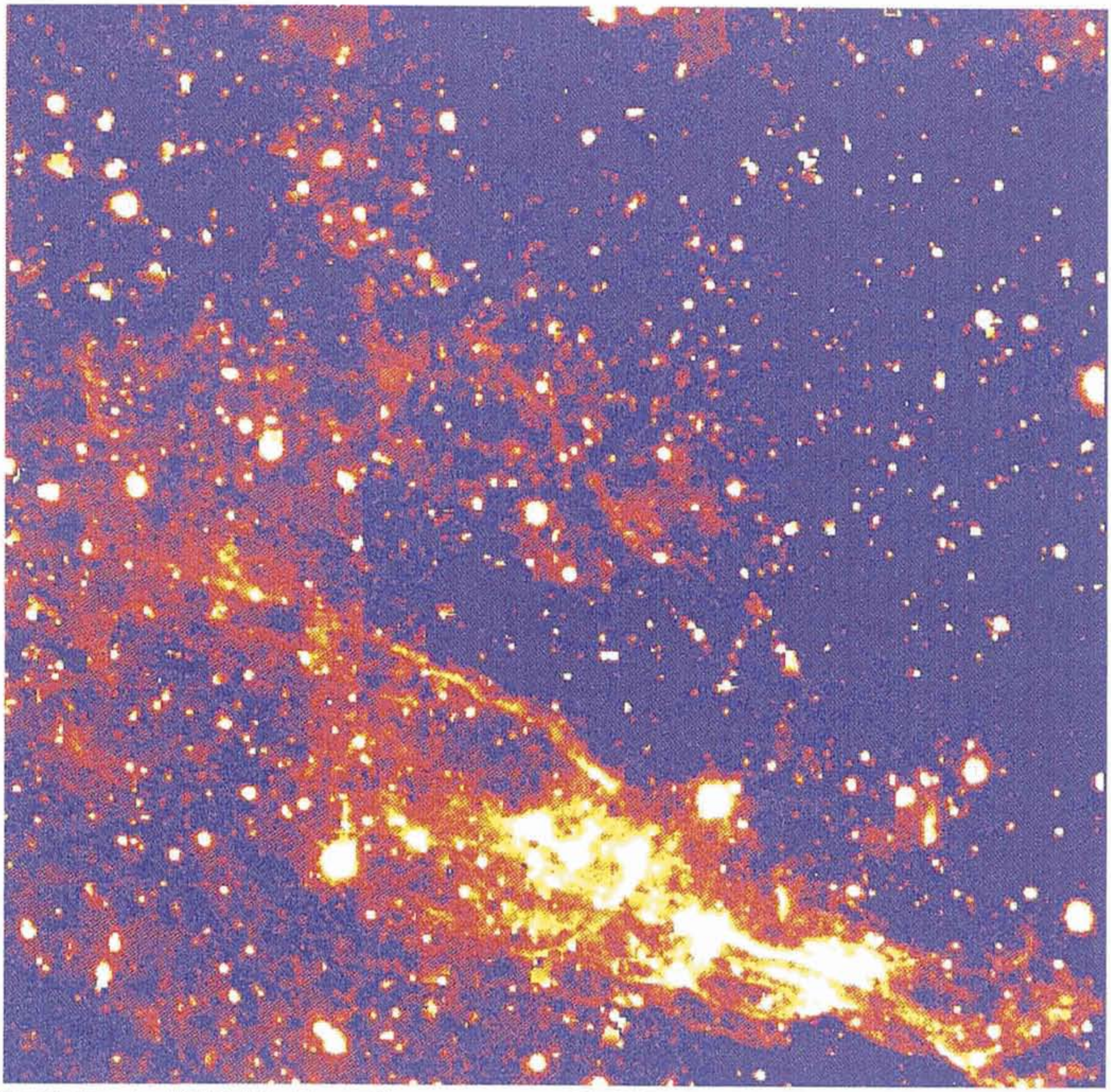

Figure 2: *Narrow band [FeII] (1.644 μm) image of the supernova remnant RCW 103. This is a mosaic of nine 4-min exposures combined to yield a field of 5×5′. N is at the top and E to the left. (Image processing; Reynier Peletier).*

The Influence of the Pinatubo Eruption on the Atmospheric Extinction at La Silla

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The atmospheric extinction is an important parameter for the reduction of photometric measurements. Besides daily, seasonal and other long-term variations (e.g. Rufener 1986) there are occasionally significant increases of the extinction coefficients due to major volcanic eruptions that induce large amounts of aerosols into the stratosphere at altitudes between 20 and 30 km. These aerosols are distributed over wide areas of the earth's surface by the stratospheric jet streams and subsequently influence astronomical observations even far away from the parent volcano. Examples of the influence of volcanic eruptions on the extinction have been given by Moreno and Stock (1964) (Mt. Agung, Bali, 1963) and Rufener (1986), Lockwood et al. (1984) (El Chichón, Mexico, 1982). Eruptions of a similar strength happen about 30 times per century, most of them in the geologically active zone around the Pacific Ocean.

On June 14/15, 1991 (JD 2448422), Mt. Pinatubo on the island of Luzon in

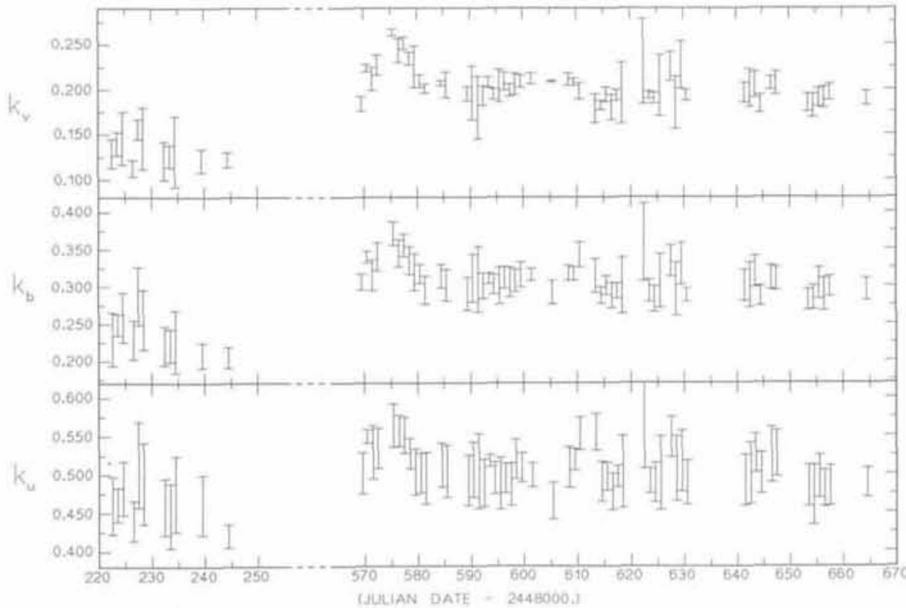

Figure 1: *Extinction variations.*

the Phillipines ($\varphi = +15°$, $\lambda = +120°$) erupted violently, throwing out in total 3–5 km^3 of dense rock (e.g. Bernard et al. 1991). it was amongst the largest eruptions of this century. The height of the Plinian column reached nearly 30 km on June 15, and ash falls were observed as far as Thailand and Singapore more than 2000 km away. The ejected SO_2 has been converted in the stratosphere into H_2SO_4 during the first two weeks and was distributed in a 2.5 km thick layer in about 18 km height (Kerola and Timmermann 1992).

As a part of an extensive photometric programme in the LMC we measured two long consecutive time series of UBV extinction coefficients (k_u, k_b, k_v) with the Bochum 61-cm Telescope at La Silla: one shorter series between November 26 and December 18, 1990, before the Pinatubo eruption, and a longer one from November 8, 1991 to February 13, 1992, after the eruption (Gochermann et al. 1992). This provides the opportunity to compare the atmospheric extinction at La Silla with and without the entry of volcanic aerosols into the atmosphere.

Figure 1 shows the variations of the coefficients k_u, k_b and k_v for both time intervals. The 1990 data fit closely to the standard extinction coefficients for an average photometric night sky at La Silla found from measurements at the Bochum telescope since 1969. There is, however, an obvious increase of the extinction in all three bandpasses in the 1991/92 data with respect to 1990. The typical extinction coefficients and the differences between the time averaged coefficients of 1990 and 1991/92 are listed in Table 1. Within the errors the discontinuities compare quite reasonably to the findings of Rufener (1986) concerning the El Chichón eruption in March/April 1982. Another confirmation comes from extinction measurements with the 20″ telescope at SAAO Sutherland in South Africa, also made between November 1991 and February 1992 (Kilkenny 1992). From these data we find the following Δk_{20} with respect to the standard extinction values: $\Delta k_u = 0.08$ mag AM^{-1}, $\Delta k_b = 0.07$ mag AM^{-1}, $\Delta k_v = 0.06$ mag AM^{-1}. At the Kitt Peak Observatory on the northern hemisphere Landolt (1991) found $\Delta k_u = 0.10$ mag AM^{-1}, $\Delta k_b = 0.12$ mag AM^{-1}, $\Delta k_v = 0.08$ mag AM^{-1}.

The additional extinction caused by the Pinatubo eruption seems to be wavelength independend within the errors at La Silla as well as at both other observatories. This relation yields a particle size of 0.35 μm calculated from the Mie theory (Kerola and Timmermann 1992) agreeing well with the particle size proposed by Rufener (1986) for El Chichón (cf. Bernard et al. 1991, Pallister et al. 1992).

No significant decrease in the high level extinction during the nearly 100 days of our 1991/92 campaign points towards an end of the volcanic contamination of the atmosphere. A possible decrease should be less than 0.01 mag AM^{-1} in 100 days for all bandpasses if the clear bump around November 13, 1991 (JD 2448574) is omitted. Seasonal effects as discovered by Rufener (1986) could, however, superpose a long-term decrease during our comparably short observation run. Furthermore, Rufener has shown that the removal of small volcanic dust particles from the stratosphere will probably take 10 to 20 years.

Our measurements reveal again that stratospheric volcanic aerosols substantially influence the extinction at all optical photometric bandpasses. The average extinction coefficients are increased by values of 0.05 to 0.08 mag AM^{-1} remaining on this high level for more than 100 days, probably even for several years. For a so far indefinite time, photometric measurements – at least at southern hemisphere observatories – should therefore not be corrected using the standard extinction coefficients. This is even more important as fluctuations (probably due to inhomogeneities in the volcanic dust layer) like the bump in November 1991 may increase the extinction considerably on a timescale of a few days. Peak values of $k_v \approx 0.3$ mag AM^{-1}, $k_b \approx 0.45$ mag AM^{-1} and $k_u \approx 0.6$ mag AM^{-1} can be reached in such bumps.

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Table 1: *UBV extinction coefficients at La Silla*

	Mean Extinction Coeff./mag AM^{-1}			Pinatubo 1991	El Chichón 1982[1]
Filter	Standard	1990	1991/92	$\Delta k_{\lambda,0}$/mag AM^{-1}	$\Delta k_{\lambda,0}$/mag AM^{-1}
U	0.459	0.457±0.022	0.514±0.028	0.057±0.036	0.070
B	0.212	0.232±0.019	0.314±0.025	0.082±0.031	0.055
V	0.125	0.130±0.014	0.208±0.023	0.078±0.027	0.048

[1] Rufener (1986)

350 GHz SIS Receiver Installed at SEST

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L.-A. NYMAN, W. WILD and G. DELGADO, SEST, La Silla

At SEST an SIS receiver for the 350 GHz (0.8 mm) atmospheric window was installed during the maintenance period of April/May 1992 and is now available to the astronomical community. The receiver was built by Chalmers University of Technology, Sweden.

The receiver is tunable from 328 GHz to 354 GHz with the present local oscillator. Single sideband temperatures are between 320 K and 480 K across the band, with a minimum at the CO J=3-2 frequency at 345 GHz (see Fig. 1).

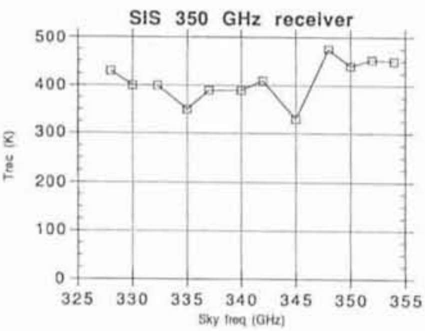

Figure 1.

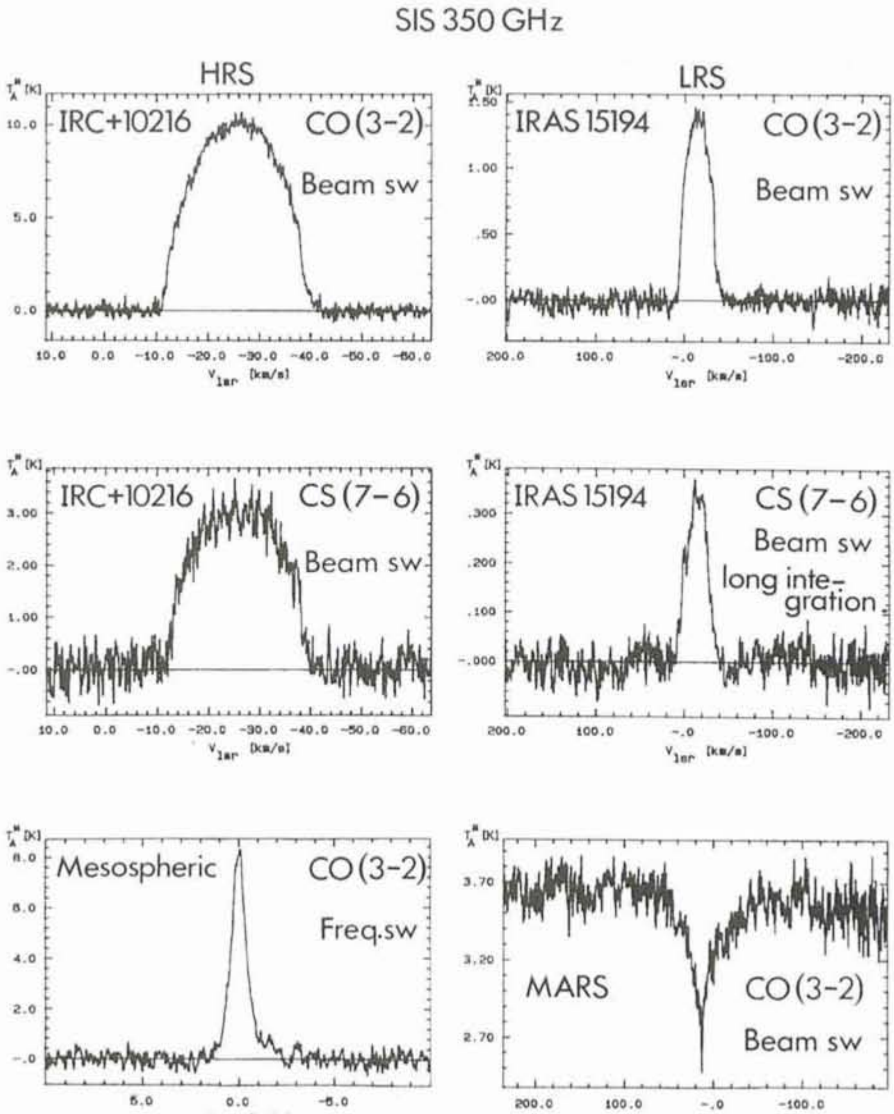

Figure 3.

Due to a long bad weather period, test observations with the new receiver could be performed only for one day. During these observations the receiver temperature was 330 K (SSB), zenith opacity between 0.6 and 0.8, and the lowest system temperatures above the atmosphere were just above 1000 K. The receiver is easy to tune, and was used in the three observing modes, position switching, beam switching and frequency switching. From an azimuth and elevation scan across Mars (Fig. 2) we derive a FWHM width of the 350 GHz beam of 15″ in both directions, with sidelobes below the 15 % level. A scan across the moon shows a wide low level error lobe with an extent of about ± 2.5′ (arcmin). The aperture and beam efficiency at 345 GHz, derived from observations of planets, are 0.16 and 0.25 respectively.

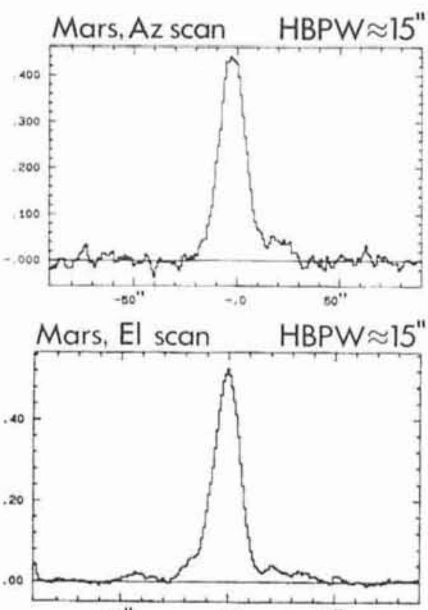

Figure 2.

Figure 3 shows some of the spectra obtained during the test observations. We measured the CO J=3-2 (345.8 GHz) and CS J=7-6 (342.9 GHz) emission towards IRC+10216 and IRAS 15194 in beam switch mode. No baselines were removed. The quality of the baseline after a long integration can be seen in the CS J=7-6 spectrum of IRAS 15194 (integration time 68 minutes). Also shown are the mesopheric CO J=3-2 line obtained in frequency switch mode, and the CO J=3-2 absorption in Mars' atmosphere.

Fine Telescope Image Analysis at La Silla

A. GILLIOTTE, ESO-La Silla

With the arrival of the NTT at La Silla a new and powerful instrument for telescope testing was added to our telescope alignment facilities.

The automated Shack-Hartmann instrument mounted with a CCD detector was developed for the NTT quality analysis required for the prime mirror surface correction and secondary mirror movement of the active optics concept.

A portable version of the Shack-Hartmann has also been developed under the name of ANTARES.

During the last year, all La Silla imaging telescopes have been tested. The Antares software has been improved and it is possible now to obtain in only a few minutes the third order aberrations (spherical aberration, coma, astigmatism, . . .) of the telescope optics. A map representation of the higher order "aberrations" over the telescope pupil is also available and we commonly call it the map of residuals.

The telescope analysis power of Antares is very high and often complex to interpret. Antares results indicate all optical aberration effects occurring in the telescope light beam, including the pure aberrations of the optical system and the thermal (bubble or convection) high-order aberrations. Antares analysis gives a complex and accurate average of the optics and the light beam aberrations.

With a large number of analyses, Antares results may be more easily divided into the two separated aberration effects, the telescope optics (mirror deformations and collimation errors) and the thermal activity (bubbles and convection effects in the light beam).

The experience gained over the past year has confirmed the importance of the Antares analysis; not only can the telescope be better aligned, but precise information about the thermal effects has also become available.

The light beam thermal activity depends on three effects: the external seeing (normally averaged with as correct integration time of the star image exposure), the dome seeing and the local air effect or mirror seeing. With appropriate, precise temperature measurements performed during the Antares analysis, a measure of the dome seeing becomes available and improvements are then possible. We already note a dramatic decrease of the high frequency aberration residuals for the classical dome when the dome slit is turned towards the wind direction (ventilation effect of the heating source in the dome). A minimum of 5 m/s is required to ventilate correctly the dome. A wind stronger than 15 m/s increases the telescope instability and produces oscillations. With no wind the telescope quality is dominated completely by the thermal contribution.

On a few occasions, stable thermal effects attributed to local air motions disturbed the telescope aberrations over a period of more than 30 minutes. Spherical aberration, astigmatism and coma can be affected strongly by the local air (air bubbles). Convection of a warm main mirror surrounded by cold air increases drastically the high frequency aberrations and the rms residual can rise to a bad value close to 1 arcsec. The residual maps performed for each sequential analysis show inconsistency in this case. Averaging of all residual maps shows the stable local defects over the telescope pupil attributed to mirror figuring errors (although there is no information about which of the mirrors).

Almost all telescopes tested suffered from spherical aberration. The Antares analysis allows a correction of the spherical effect by a modification of the instrument position along the telescope axis. Discrepancies between theoretical and real matching of primary and secondary mirrors produced the spherical errors. Antares is the best tool to adjust properly the primary-secondary mirror separation, thereby determining the nominal telescope focus position where the entrance reference surface of all instruments must be located. The principle of telescope focusing for different instrument positions by moving the secondary mirror is wrong. Telescope focusing should be used only for compensation of small mechanical changes of the telescope structure due to temperature variations.

Telescope quality testing has also been performed successfully with Antares at other Observatories.

The basic telescope quality is generally good (except for the too large spherical aberration); 80% energy is concentrated within subarcsec values and the thermal effect dominates mostly the final telescope quality.

It is now fundamental to avoid too much thermal activity in the telescope area if high imaging quality is wanted. All heat sources must be removed and a good dome ventilation (with air fans) will improve the air exchange between the exterior and the dome. NTT analysis experience has shown how it is possible to improve the dome design.

However, it would be best to use the telescope without any dome at all!

The Dust War

A. GILLIOTTE, P. GIORDANO, A. TORREJON, ESO

Telescopes on terrestrial sites suffer of an unavoidable phenomenon disturbing high-quality astronomical observations: Dust pollution.

By the term dust we include all different kinds and sizes of organic and mineral particles. Effects on astronomical observations can be really critical. A great deal of progress has been made recently to improve the optical quality of modern ground-based telescopes and it is quite easy to keep the telescope performances at a consistent level of high optical quality. We must preserve high signal throughput and low noise level. Regular cleaning will increase the lifetime of the coating and optical surfaces, thus improving safety by reducing also the frequency of handling.

Past experience at La Silla shows that the average loss of mirror reflectivity is of the order of 10% per surface and per year. Our present recoating periodicity is of the order of 2 to 2½ years. A loss of reflectivity of 35% after two years also means that even with very good seeing conditions the dust contamination becomes the main factor reducing the performance. Image contrast is also reduced by optical surface diffusion and the surface emissivity produces serious contrast and sensitivity limitations on IR observations.

A monthly cleaning procedure will remove 90% of all the limiting effects above listed. Recoating frequency will be decreased to four-year intervals. The longer interval is also fundamental in maintaining the quality of polish, which is inevitably reduced by cleaning for aluminization.

Dust deposition is not only a direct effect from our atmosphere, contamination rates increase also drastically with human activity on the telescope area. Dust lies on the optical surface and, after a period of months with varying climatic conditions, the dust adheres to the surface by either physisorption or chemisorption. Adherence force may reach more than 100 g with physisorbed submicron-sized particles. Organic or even mineral dust may become glued to the surface by chemisorption with water or condensation solution droplets. Severe localized mirror corrosion may occur producing the spots, transparent to light, classically seen on old aluminium mirror coatings. Then the dust removal becomes impossible by air blowing only and washing (with mechanical action) is required to overcome the sticking forces of the dust particles.

Two directions must be pursued to limit dust contamination: We must first try to decrease the dust rate deposition by avoiding unnecessary dirt-producing activities in the telescope and instrumentation areas. Then a periodical cleaning of optics must be scheduled to remove the direct dust contamination before either physisorption or chemisorption have fixed the particles on the surface.

It is an easy matter to obtain rapidly a growing awareness of the importance of keeping telescope and instrumentation areas as clean as possible. Opticians will have the important task to survey the dust contamination and to perform careful optical part cleaning.

Figure 1: *CO_2 cleaning.*

Systematic and thorough cleaning of the dome and telescope structures have been operating for half a year with the help of all the La Silla team. Awareness of cleanliness requirements of all people involved in telescope work will be the major challenge of high-performance optics.

Two optical surface cleaning techniques will be used at La Silla: The pure carbon dioxide snowflake jet is used on a monthly basis to remove the dust accumulation over the surface. This method is a rapid and easy-to-use technique; only a few minutes are required to clean a four-metre-telescope mirror. Time is consumed only during the cleaning preparation (CO_2 bottle with adequate pipe length to reach the mirror). CO_2 liquid is throttled through a nozzle and expanded at atmospheric pressure into a special plastic tube oriented with around 45° inclination towards the mirror surface. The resulting snowflake jet removes dust without any damage of the aluminium surface, the flakes slide over the surface on a cushion of CO_2 gas and leave no residues behind. Dust is removed with different physical effects from those of a gas blowing and particles sticking over snowflakes crystals. The procedure is applied on an inclined mirror (telescope orientation greater than 45° Zenithal distance) and gravity allows dust and residual snow to move down and out of the mirror surface. Figure 1 shows the cleaning method. Some dust residuals remain on the surface (physisorbed submicron-sized particles with the strongest sticking forces), the CO_2 cleaning allows a reflectivity increase to 90% of the fresh coating.

The peeling technique allows an almost complete reflectivity recuperation. However, application on large surfaces is delicate and time consuming. We foresee a peeling cleaning every year or every six months, depending on future

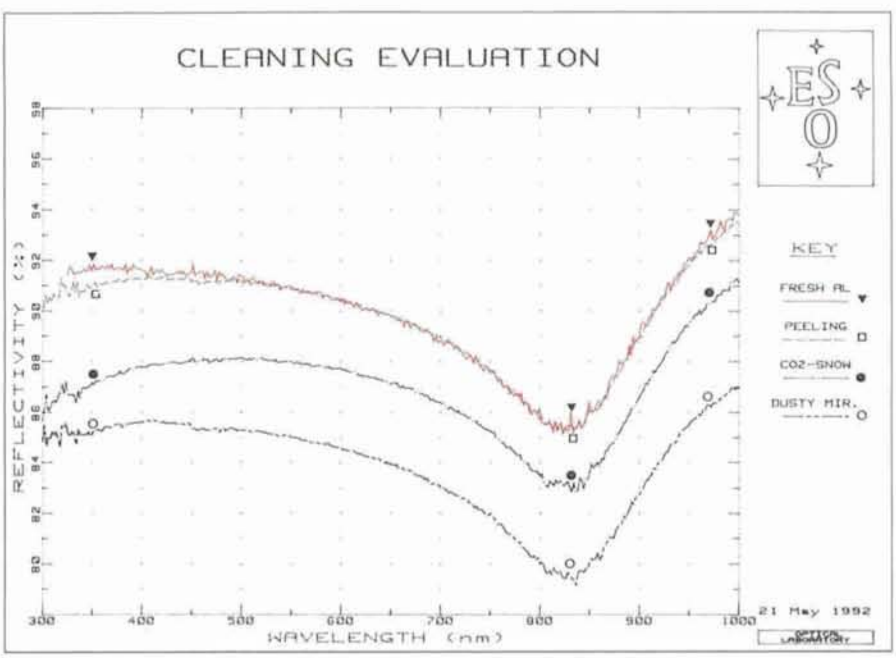

Figure 2: *Comparison of cleaning techniques.*

experience. Fortunately, lacquer products are now available in spray cans which will simplify the application.

Various cleaning tests have been performed either at La Silla or Garching. Figure 2 shows the cleaning efficiency of the CO_2 snowflake and peeling technique on a mirror exposed to dust contamination. Recent scattering and reflectivity measurements have been performed on test mirror samples with four conditions of the mirror surfaces, the original coating being protected with a cover to obtain the reflectivity and scattering reference of data, half the dirty surface then cleaned with CO_2 jet and peel-off-lacquer. The results confirm the efficiency of the two procedures.

A project for an automated pilot CO_2 cleaning device for the NTT main mirror is at the stage of a call for tender at the ESO Headquarters. Mirror cleaning will be performed with CO_2 snowflake jets on a rotating arm.

Cooperation concerning the cleanliness of the observatory, telescopes and instruments will be greatly appreciated. Maximum efficiency in astronomical observations make these efforts mandatory.

Adaptive Filtering of Long Slit Spectra of Extended Objects

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1. Introduction

In both galactic and extragalactic astronomy, long-slit spectroscopy has proven to be a useful tool to study the physical properties of extended objects.

In the last two decades, CCD detectors coupled to spectrographs, while on the one hand simplifying some aspects of the processing of 2-D spectra – such as, for instance, the need for correcting the S-distorsion introduced by the image tubes –, on the other hand have allowed to reach fainter light levels thus arising the need for a careful removal of all sources of noise.

One of the most extreme examples is the study of the kinematical properties of the stellar component in early type

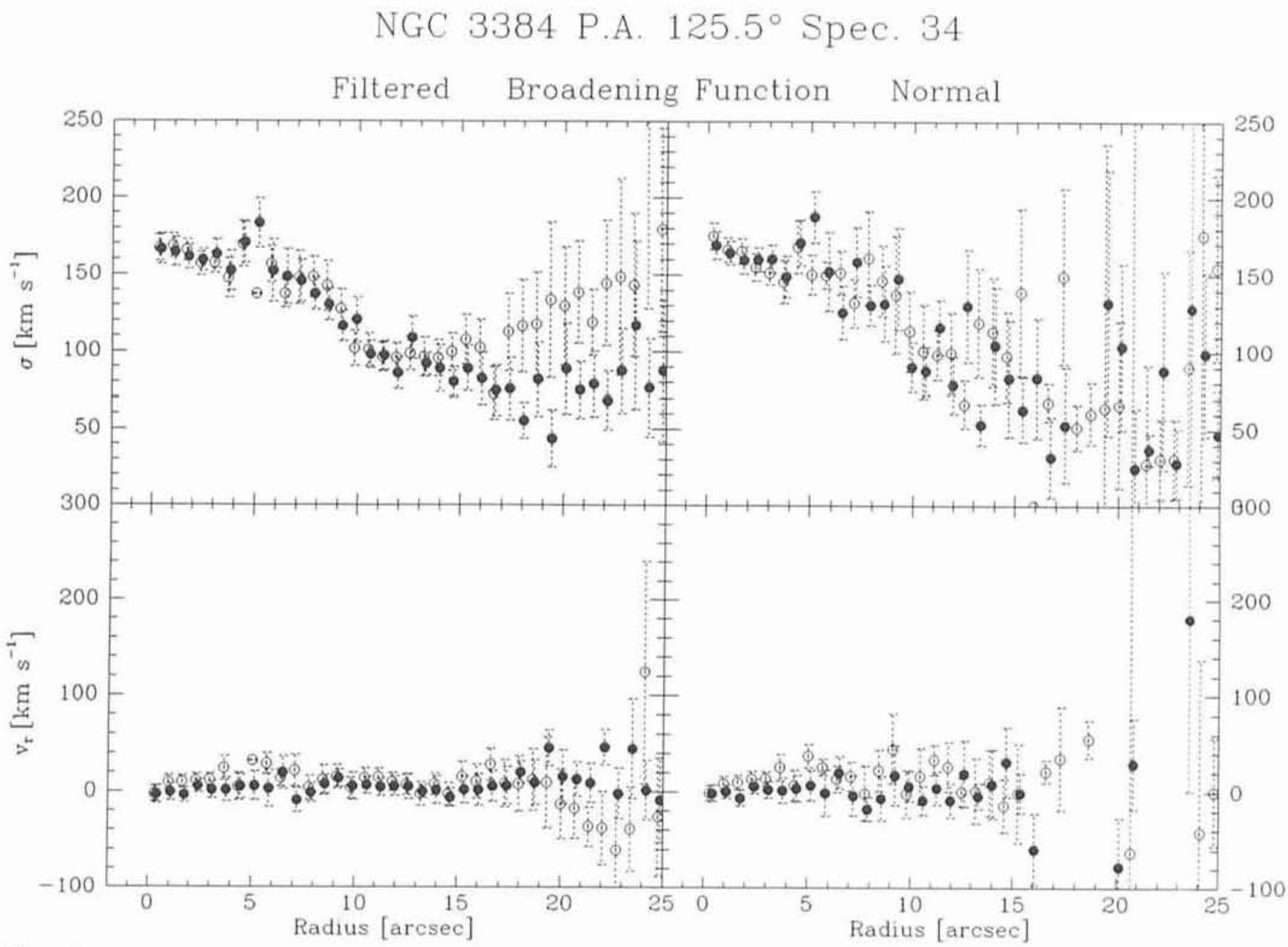

Figure 1.

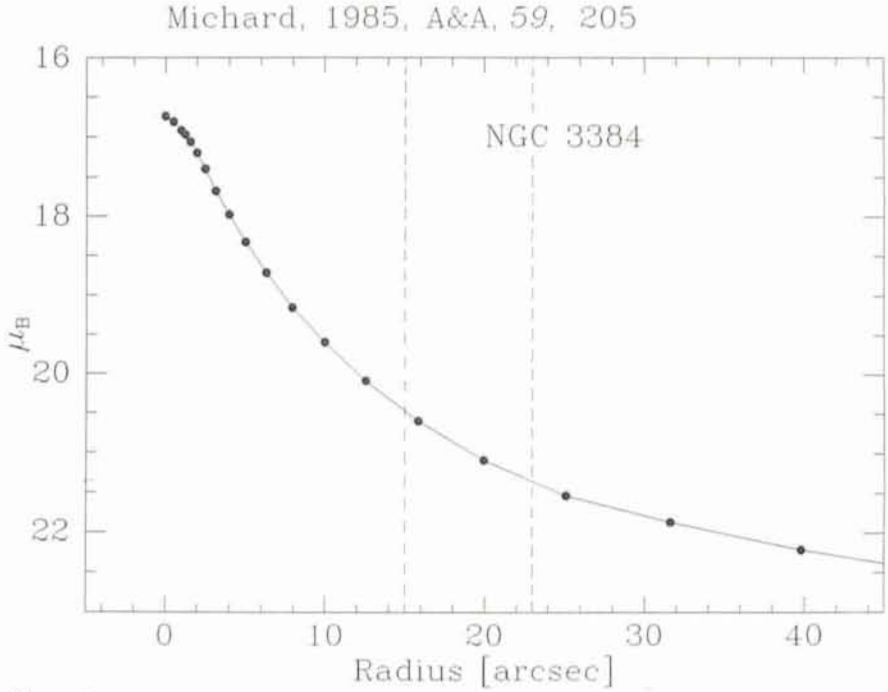

Figure 2.

galaxies or in the bulges of spirals by means of faint absorption features. As pointed out by several authors (Capaccioli and Longo, 1990; Kormendy and Djorgovski, 1989; Busarello et al., 1992), the understanding of the intrinsic structure, dynamics and overall properties of early-type galaxies requires to have radial velocity curves and velocity dispersion profiles as much extended as possible. Unfortunately, the fact that absorption lines are broadened by the velocity dispersion of the stellar component and the sharp decrease with radius in the surface brightness of galaxies render very difficult to go beyond 1.0 – 1.3 effective radii, i.e. beyond the region where the sky background becomes dominant. It needs to be pointed out, however, that even in the few cases where distances as large as 2.0 effective radii could be reached by adopting special and very time consuming observing and data-reduction strategies (Cappellaro et al. 1989), the data could not be fully exploited.

This being mostly due to the fact that in usual data reduction, after the standard flat fielding, the correction for particle events and bad pixels have been performed and after the sky background has been corrected for, there is still a broadband component of the noise due to the read-out of the CCD and to the electron noise, which prevents us from reaching fainter levels of surface brightness.

In the case of absorption-line measurements, the standard analysis methods such as, for instance, the cross-correlation or the Fourier quotient techniques, have already some capability to overcome the noise but in the direction of the dispersion only. In the direction perpendicular to the dispersion, the noise reduction is problematic and the usual stationary filtering technique cannot be used without destroying the resolution in the central part of the galaxy. The only way to overcome this limitation is to build a filter having a reasonable window size in the outer and fainter parts of the spectrum and capable of adapting to the local resolution by shrinking in the inner parts. Such an adaptive filter, which recognizes the local resolution by using the first and the second derivative of the image and is based on the *H – transform*, has been developed and implemented for astronomical images by Richter (1978) and recently applied to the photometry of NGC3379 by Capaccioli et al. (1988).

Table 1: *Characteristics of the spectra*

Spectrum Id.	Object Id.	P.A.	exp. time	date	tel	λ range
69	NGC1553	69	4500	01/02/90	2.2	4660-5500
27	NGC3384	125	2820	12/04/89	1.52	4400-5800
34	NGC3384	126	5400	12/05/89	1.52	4400-5800
78	NGC7176	78	4500	07/15/90	1.52	4600-5600

Table 2: *Characteristics of the observed galaxies.*

Object Id.	Type	P.A.	B_T	$A_e/2$
NGC 1553	S0 pec.	150	10.28	60"
NGC 3384	LBS	53	10.85	25"
NGC 7174	S pec.	88	14.23	
NGC 7176	E pec.	–	12.34	

In direct images, however, the structure of both the noise and of the signal is isotropic, while in the case of spectra, it is necessary to filter only in the direction perpendicular to the dispersion, and leave completely untouched the noise and the signal in the direction of the dispersion (where the analysis methods deal properly with the noise). After such a filter has been applied, the cosmic-ray events and the stronger noise peaks are left untouched. In order to remove them we applied a 3×3 pixels Laplace filter, which has the property to enhance all spikes over a more or less constant background. The subsequent comparison of each spike with the point-spread function allows to discriminate between signal and noise events.

2. Results

In order to test the above-described procedure, we applied it to a set of spectra obtained with the ESO 1.52-m and 2.2-m telescopes plus the Boller and Chivens spectrographs during several observing runs in 1989 and 1990.

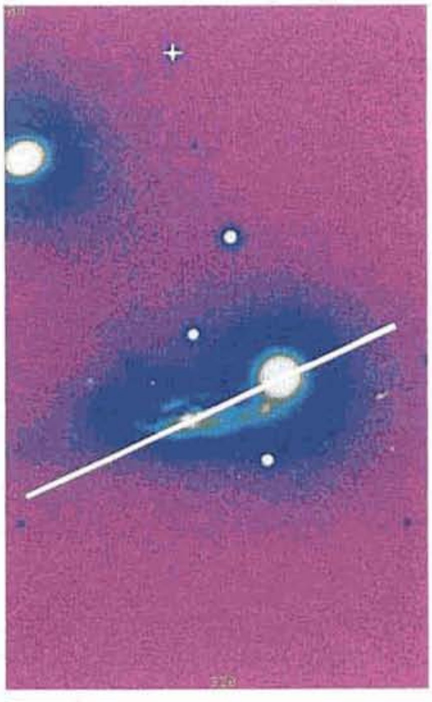

Figure 3.

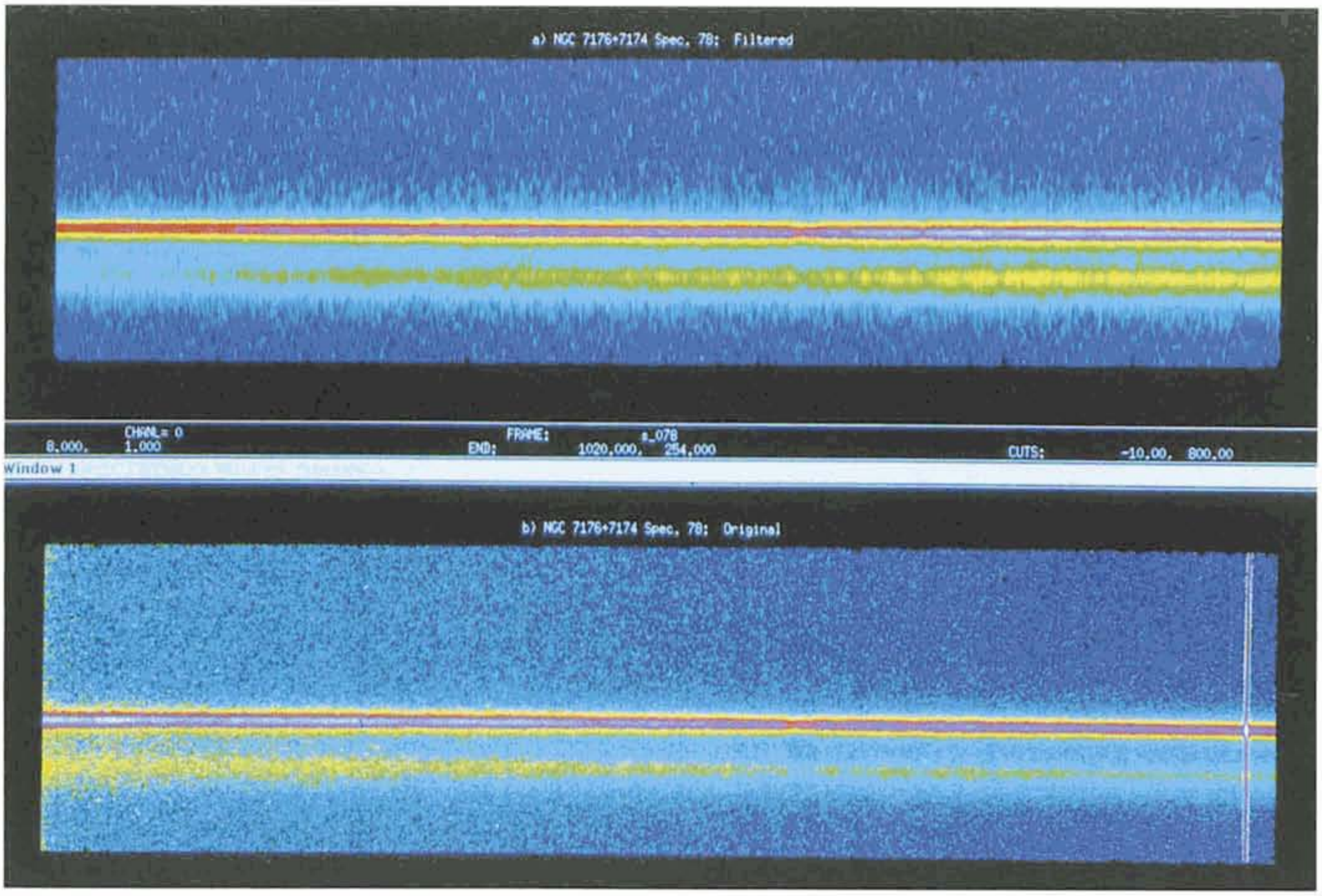

Figure 4.

The spectra were taken as a part of a project on the kinematics of early-type galaxies and are detailed in Table 1. Table 2, instead, gives some relevant information about the observed galaxies. Objects NGC 7174 and NGC 7176 belong to the Hickson group n. 90.

All spectra were processed twice: in a first reduction run, they were processed following standard MIDAS routines for flat fielding, bias and dark subtraction, sky background subtraction and wavelength calibration. The spectra were then analysed using the Fourier correlation quotient method kindly made available to us by Bender (1990), which consists in the deconvolution of the peak of the galaxy vs. template cross-correlation function with the peak of the autocorrelation function of the template star. In the second reduction run, after the standard pre-processing, the spectra were filtered accordingly to the procedure described in the previous paragraph and then analysed exactly in the same way as in the first case.

Figure 1 shows the radial velocity (bottom) and the velocity dispersion profiles (top) obtained from spectrum 34. Both profiles are folded over the photometric baricentre, and the opposite sides of the galaxy are marked with different symbols. "Filtered" data are

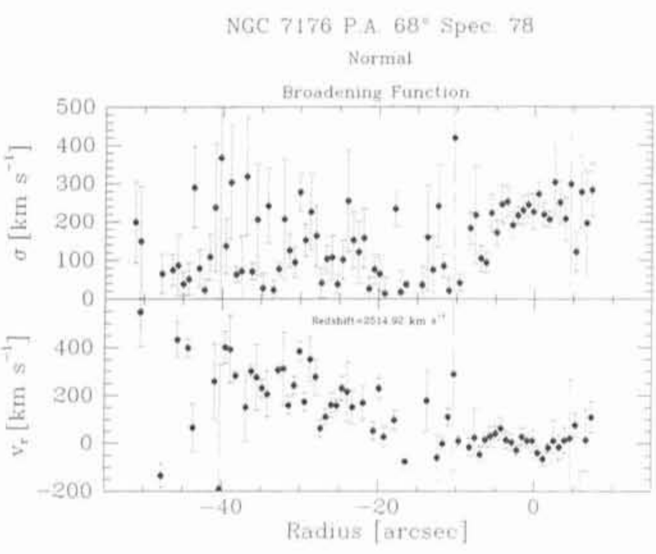

Figure 5.

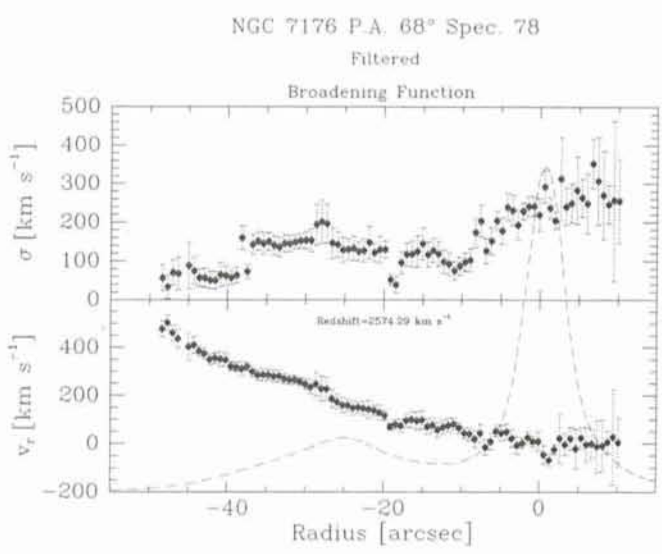

Figure 6.

shown on the left side, while normal – i.e. "unfiltered" – data are on the right one. The spectrum was taken at a position angle differing very little from the direction of the minor axis of NGC 3384 and, as expected, no rotation is found. Even though the definition of the last meaningful point is somewhat arbitrary, it is evident that, even with a conservative estimate, the filtered data extend out to 23 arcsec, while the normal data reach out to about 15 – 16 arcsec. The comparison with the luminosity profile given in Figure 2 shows that the adaptive filtering of the data allows to go almost 1 magnitude fainter in surface brightness than with the normal approach. In the inner region, the two sets of data match very well even though the internal error in the filtered data is much smaller.

The fact that adaptive filtering is very effective at very low light levels is confirmed by the results obtained for spectrum 78. Figure 3 is a CCD image of three members of the Hickson group n.90: the two bright ellipticals are NGC 7173 (left) and NGC 7176 (right), while the spiral close to the centre of the image is NGC 7174. The line marks the position of the spectrograph's slit, which covered both NGC 7176 and NGC 7174, Figure 4a shows the raw image of spectrum 78, while Figure 4b shows the same spectrum after preprocessing and adaptive filtering. Figures 5 and 6 give, respectively, the radial velocity and the velocity dispersion profiles in the "unfiltered" and "filtered" cases. The overimposed solid line gives the luminosity profile along the slit in an arbitrary scale.

An empirical test of the reliability of the results may be inferred by the comparison of Figure 7, which gives the radial velocity curve obtained from the "filtered" spectrum n.27, and the curve

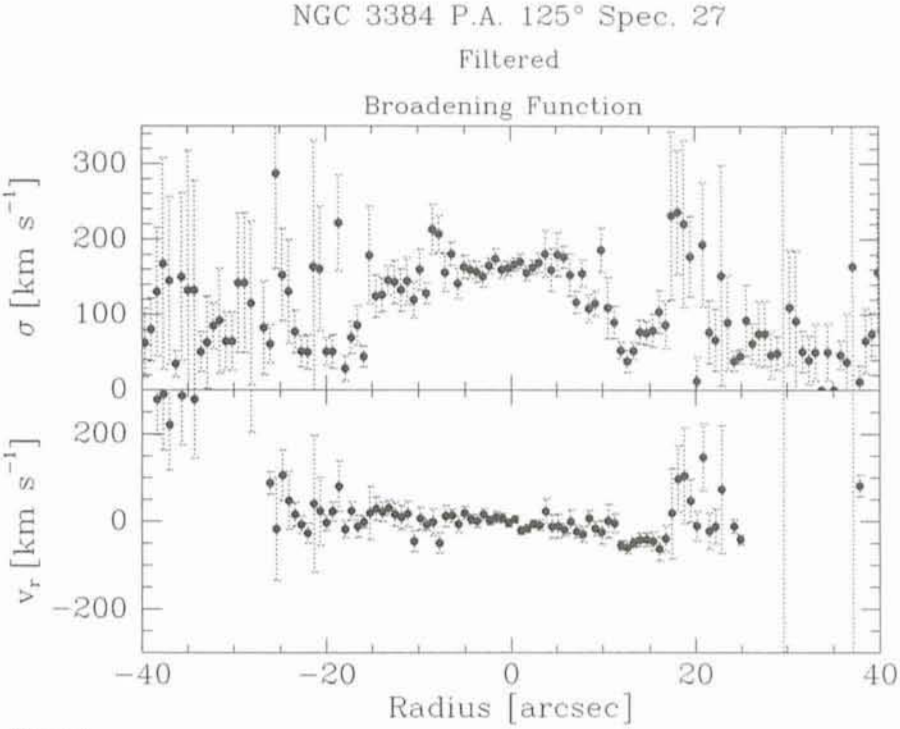

Figure 7.

(obtained from spectrum n.34) shown in Figure 1.

The different exposure times imply that the same signal-to-noise ratio is reached in spectrum 34 at a level 0.7 magnitudes fainter than in spectrum 27, thus partially compensating the effects of the filtering procedure. The match between the two radial velocity curves is quite good. A further test of the reliability of the method is shown in Figures 8 and 9, where the radial velocity curve of NGC 1553 obtained by filtering spectrum 69 is compared to the rotation curve published by Kormendy (1984 = K84). The K84 data were obtained by using the 4-m KPNO telescope+ RC spectrograph+image tube+Kodak IIIa-J, with a spectral resolution comparable to our set of data. The total exposure time for K84 was 6.5 hours. Taking into account that the quantum efficiencies of the two instrumental set-ups are more or less comparable and that both the collecting area and the exposure time are largely in favour of the K84 data, the good agreement between the two sets of data is a striking confirmation of the reliability of the adaptive filtering technique.

Acknowledgements

This work was partially sponsored by the Italian Space Agency (A.S.I.). G.R. acknowledges a grant by the Italian

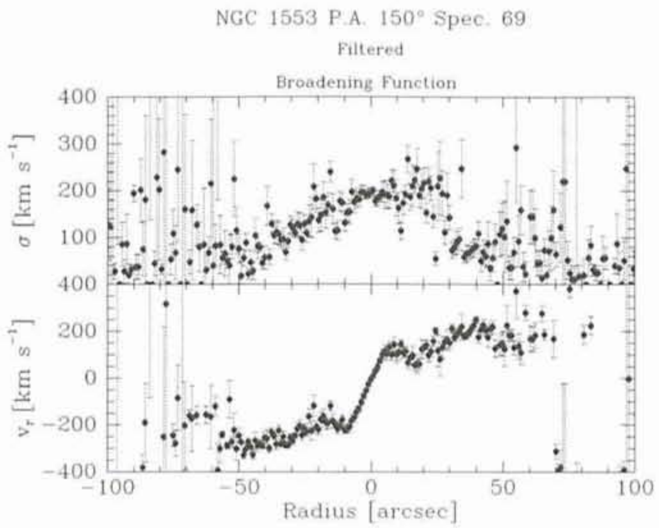

Figure 8.

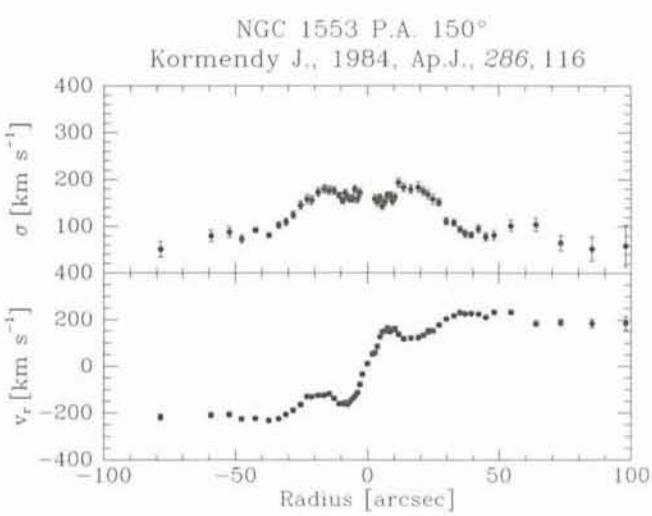

Figure 9.

CNR (National Council of Research); S.Z. acknowledges DIGITAL-Italia for granting a fellowship.

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The Determination of the Dead-Time Constant in Photoelectric Photometry

E. PORETTI, Osservatorio Astronomico di Brera, Milano, Italy

It is a well-known fact that raw counts measured at the output of a photon-counting photometer must be corrected for the dead-time constant τ. This correction originates from the finite time interval necessary for the electrons to cross the photomultiplier tube and, overall, from the time necessary to the amplifier/discriminator electronic to record the output pulse. From a practical point of view, this means that the instrumentation cannot resolve two incident photons separated by a time shorter than τ since they will be counted as a single event. Hence, the output counts will always be an underestimate of the input value.

Photons are travelling clumped together in space and the correction term can be calculated by means of the Bose-Einstein population statistics. The probability density f(t) that two photons arrive separated by a time t is

$$f(t) = \lambda e^{-\lambda t}$$

where λ is the arrival frequency of the photons. n_τ, the number of photons which arrive in a time interval shorter than τ, is given by

$$n_\tau = N\int_0^\tau f(t)dt = N\int_0^\tau \lambda e^{-\lambda t}\,dt,$$

while N is the total number of photons arrived during the measurement time. If it is 1 s, we have $N = \lambda$. By integrating, we obtain

$$n_\tau = N(1 - e^{-N\tau})$$

and, if we indicate as n the photons actually counted,

$$n = N - n_\tau = \frac{N}{e^{N\tau}}$$

This is the relation between the number of incident photons N and the number of counted photons n. If we can suppose that $N\tau$ is small, we can approximate $e^{N\tau}$ with a McLaurin development stopped at the first order, obtaining

$$n = \frac{N}{1 + N\tau} \qquad N = \frac{n}{1 - n\tau}$$

The latter is the formula most widely used in data-reduction routines. The value of the τ constant is generally supplied by the manufacturer and it is reported in the users manuals without any further checks. In general this assumption is justified by the impossibility to perform accurate laboratory tests. In some cases, the dead-time constant is confused with the rise time (i.e. the time interval during which the output rises from 10% to 90% of peak output) and its value is therefore underestimated. In the dome, astronomers can directly calculate τ by measuring two standard stars, one much brighter than the other, and comparing the observed Δm with the expected one.

However, this method requires a very precise knowledge of the magnitudes of the two stars and of the extinction coefficient. Cooper and Walker (1989, "Getting the measure of the stars", Adam Hilger Publ.) report a method which seems to me much more practicable. The telescope should be pointed towards sunrise and, when the sky is brightening, sky measurements should be performed alternating two different diaphragms, one much smaller than the other; let α be the ratio of their areas. An upper limit should be fixed to satisfy the following conditions: it should not be too high to cause damages to the photomultiplier or, from a more formal point of view, to invalidate the McLaurin development, but it should not be too small to make the linear fit described below uncertain. Weighting these factors, we can establish a maximum rate of 1.2 10^6 counts per second. Sunrise should be preferred to sunset to better evaluate when this limit is reached and consequently not generate fatigue effects of the photomultiplier; as regards the observer's fatigue, moonlight can provide an alternative target ... In any case, particular care must be taken to avoid expositions to very bright light sources. We have

$$N_l = \frac{n_l}{1 - n_l\tau} \qquad N_s = \frac{n_s}{1 - n_s\tau}$$

for the large and small diaphragm, respectively. In presence of a uniformly illuminated image (bright stars should be carefully excluded from the field of view), we can calculate

$$\frac{N_l}{N_s} = \alpha = \frac{n_l}{n_s}\frac{1 - n_s\tau}{1 - n_l\tau}$$

and by means of simple passages

$$\frac{n_l}{n_s} = \alpha + \tau\,(1 - \alpha)n_l.$$

In a n_l vs n_l/n_s plane the last equation represents a line: the ratio of the diaphragm areas α is the intercept, while the angular coefficient allows us to calculate τ.

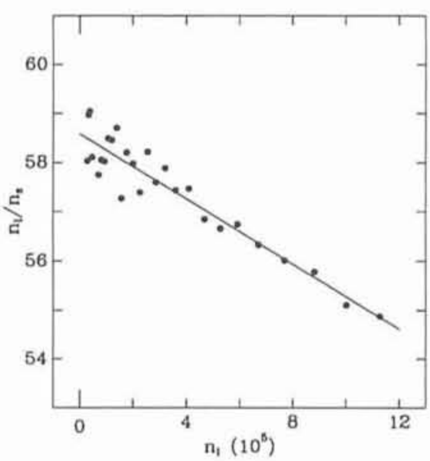

Figure 1.

Figure 1 shows the results obtained at the ESO 50-cm during sunrise on September 9, 1991 (B measurements carried out with an EMI 9789QB photomultiplier). The resulting value of the τ constant is 58 ($\pm$ 4) 10^{-9} s; a less precise, though in excellent agreement, determination (the maximum rate was only 5 10^5 counts per second) was obtained on September 5, 1991: τ = 59 ($\pm$ 19) 10^{-9} s. The measure was repeated with the same instrumentation during sunrise on April 24, 1992, and the value of 58 ($\pm$ 6) 10^{-9} s was obtained.

These values are not much different from the value reported by the manufacturer (15 10^{-9} s): the 4:1 ratio causes deviations in limit cases only (0.005 mag between two stars with a luminosity ratio of 1:10 in the range 10^4–10^5 counts per second). However, we notice that much larger deviations are expected for higher values of τ: if its value is 600 10^{-9} s, an underestimation by a factor 4 will produce a difference of 0.05 mag for the same two stars. Hence, the possibility of applying a well-determined value should not be overlooked by an accurate observer. This procedure also allows us to measure the area ratios with great precision: for example, in the figure the intercept value is 58.6 $\pm$ 0.1 (diaphragms # 1 and # 6).

Radioactive Isotopes of Cobalt in SN 1987A

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The question of the main sources of energy input powering the late time (> 900 days) bolometric light curve of SN 1987A has continued to be debated up to the present time (> 1800 days). The nature of this energy input has been examined by determining by observational means the bolometric light curve and then comparing it with theoretical predictions. After day 530 when dust formed in the envelope most of the radioactive energy was released in the infrared region longward of 5 microns. This occurred because the optically thick dust proved very efficient at thermalizing the higher energy photons which emanated from the deposition in the envelope of γ-rays emitted as a result of β-decay of radioactive species.

Unfortunately, when the dust reaches a temperature of approximately 150° K, which it had by day 1316, the bulk of the radiation occurs at wavelengths longward of 20 microns, the longest infrared point measurable from ground-based observations. Thus astronomers using this technique are somewhat apprehensive about the accuracy of the derived bolometric light curve, for fear of course, that fitting theoretical black body temperatures and extrapolating into an inaccessible region may not account correctly for all the energy beyond observable reach.

The two groups studying this late-time behaviour, ESO and CTIO, have reported differences in 10 and 20 μ luminosities at approximately the same date (Bouchet et al. 1991; Suntzeff et al. 1991). In spite of these differences and the fact that they lead to somewhat different bolometric luminosities both groups agree that now there is radiation from SN 1987A in excess of what would be produced from the radioactive decay of ^{56}Co alone. Recently the CTIO group (Suntzeff et al. 1992) and others (Dwek et al. 1992) have ascribed this excess to the radioactive decay of ^{57}Co whose abundance would correspond to 4–6 times the amount expected on the basis of the solar values of the stable nuclides of mass 57 and 56. Other energy sources such as an embedded pulsar are also considered, but considerable weight is given to the fact that the observed light curves approximate in shape the decay curve of ^{57}Co with an e-folding decay time of 391 days.

The most direct method of determining the mass of ^{56}Co and ^{57}Co has been employed by the ESO group (Danziger et al. 1991; Bouchet and Danziger 1992) over the interval 200–600 days following the explosion. This involves the measurement of the Co II 10.52 μm line emitted in the nebular phase where the strength of this emission line is insensitive to temperature and comes from the predominant ion of cobalt during this time. This method allows the determination of ^{57}Co at much earlier epochs than the method based on the bolometric light curve, because at day 500 approximately half of the total mass of cobalt would be in the form of ^{57}Co even if the original 57/56 ratio were similar to that expected from the solar ratio of stable nuclides of the same mass. The detectable effect on the bolometric light curve occurs much later (> 1000 days) because ^{57}Co decays 3.5 times slower than ^{56}Co and also deposits lower-energy γ-rays in the envelope as a result of that decay.

At the Tenth Santa Cruz Workshop on Supernovae held in July 1989 (Woosley 1991), Danziger et al. (1991) announced that the ESO measurements pointed to an original ^{57}Co/^{56}Co ratio equivalent to 1.5 times the solar value of stable 57/56 nuclides. It was stated there and subsequently (Bouchet et al. 1991, 1992) that these results could not accommodate a value of this ratio as high as 4. In addition, this method also provided a determination of the original mass of ^{56}Co = 0.070 $M_\odot$ consistent with the value determined from the bolometric light curve by Suntzeff et al. (1991) and Bouchet et al. (1991) and others. This determination of the ^{57}Co/^{56}Co ratio was subsequently supported by the results of Varani et al. (1991) who used a near-infrared line of Co II at 1.5 μ, the effects of the temperature sensitivity on which were considerably reduced by comparison with an Fe II line of similar excitation level.

As a consequence of these observations the ESO group has always sought a different explanation for the excess in the bolometric luminosity at late times.

The other direct method to determine the mass of ^{57}Co (and also independently ^{56}Co) is to measure the flux of γ-rays produced by the radioactive decay. Because some γ-rays escape the envelope and some are absorbed to support the conventionally determined bolometric luminosity, the interpretation of any such measurement is somewhat model dependent. Nevertheless, the opacity of such an envelope to γ-ray penetration is thought to be well understood.

Therefore, it is of particular interest that recently, new results from the Oriented Scintillation Spectrometer Experiment on the Compton Gamma Ray Observatory have been announced by Kurfess et al. (1992) from observations made during the intervals days 1617 to 1628 and days 1767 to 1781. They report a detection of γ-ray emission from ^{57}Co in SN 1987A consistent with an original amount equal to 1.5 times the solar value of the ratio of stable 57/56 nuclides and inconsistent at greater than a 3σ level with a value of 5 times solar.

X-ray observations searching for comptonized γ-ray radiation (Sunyaev et al. 1991) from the KVANT-MIR Observatory had previously pointed to an upper limit of 1.5 solar.

One should note also that the most preferred values of the ^{57}Co/^{56}Co ratio from the theory (Woosley and Hoffmann (1991) are in the region of 1.5 times the solar value of the ratio for stable nuclides. This deserves some weight because the theoretical models involving nucleosynthesis have been remarkably accurate in their predictions for SN 1987A, and nucleosynthesis results are not very model dependent.

Thus we have gained more confidence that the correct value of $^{57}Co/^{56}Co$ has been determined. Consequently, the excess in the bolometric light curve remains unexplained. A pulsar, an accretion disk surrounding a collapsed object, other radioactive species such as ^{22}Na and ^{44}Ti remain candidates, and further observations may in time either confirm or eliminate each or all of them.

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An Intermediate Age Component in a Bulge Field

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Much can be learned about the galactic stellar populations and structure from studies of background fields. As yet, bulge field studies have been carried out along its minor axis. These studies show a dominant old metal-rich population (e.g., Terndrup, 1988).

It would be important to observe also fields along the major axis in the hope of learning more about the transition halo-disk.

Recently we have studied NGC 6603,

a rich open cluster towards the Galactic bulge (l = 13.8°, b = –1.3°), and its associated field at 5′ north of the cluster centre.

The observations were carried out at the 1.54-m Danish telescope, using ESO CCD # 5 and the Cousins V and I filters. The reductions were done in a standard way using Midas and Daophot packages at ESO-Garching.

In Figure 1 we show the results for this 5′ north offset field, where the identified stellar components are labelled. As expected from the low latitude of the field, we see a young main-sequence (MS) coming from the disk. The magnitude range suggests an age spread of about 500 Myrs along the blue MS, as can be inferred from a comparison with a series of colour-magnitude diagrams (CMDs) for galactic open clusters of different ages by Mermilliod (1981). A sequence of red giants parallel to the young MS is present, corroborating this age spread possibility, if differential reddening is not affecting much.

The bulge metal-rich component is revealed by a populous red horizontal branch (HB) typical of metal-rich old populations (e.g., Ortolani, Barbuy and Bica, 1990, OBB90). This sequence is elongated and tilted and this effect is caused by differential blanketing and/or

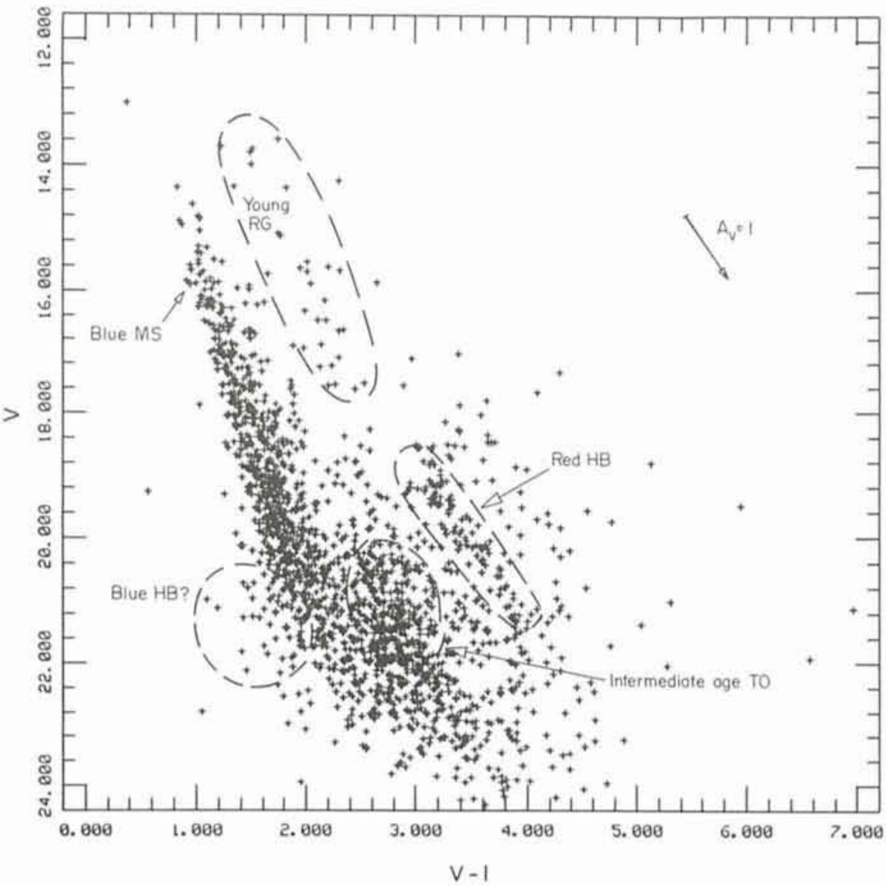

Figure 1: *V vs. (V-I) diagram of a field 5′ north of NGC 6603 (l = 13.8°, b = –1.3°).*

differential reddening effects. Some bulge giants are also present in the diagram.

To the left of the MS at V ~ 21 mag, a clump of possible blue HB might be associated with a metal-poor component (such as low-metallicity globular clusters) or a hot component of the bulge metal-rich population.

An interesting result is the presence of an intermediate age turn-off (TO) at (V-I) = 2.7 and 20.4 < V < 22, which could be interpreted as an old disk/thick disk population, or a bulge-disk transition component. Another possibility is to associate this intermediate age component to a possible bar system in the central parts of the Galaxy (Blitz and Spergel, 1991). This latter possibility is supported by the fact that an important fraction of the stellar populations in the LMC bar are of intermediate age (Bica et al., 1992).

More fields at different latitudes and longitudes across the bulge would be of great interest to reveal the spatial distribution and ages of stellar populations, in order to better understand the bulge-disk transition.

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Contents

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