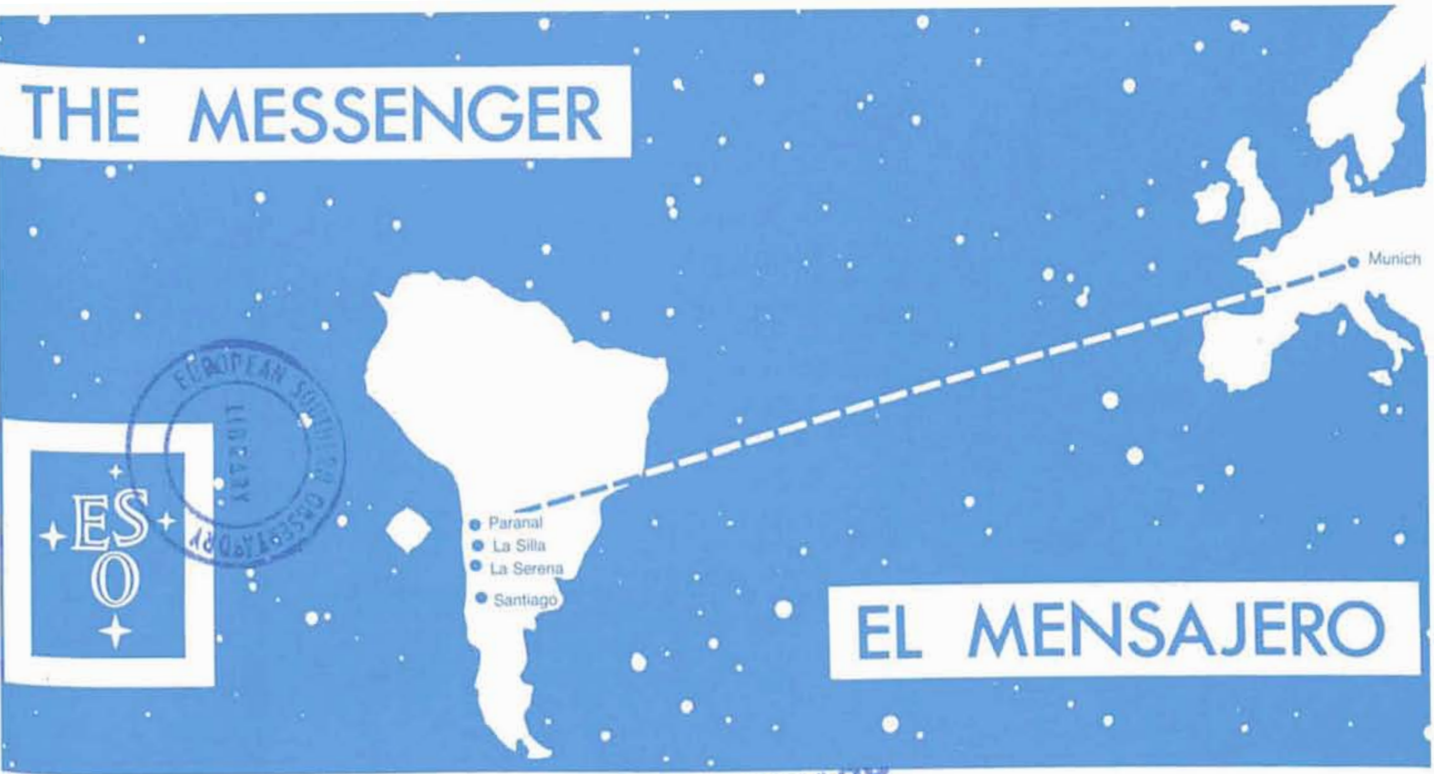


No. 65 – September 1991

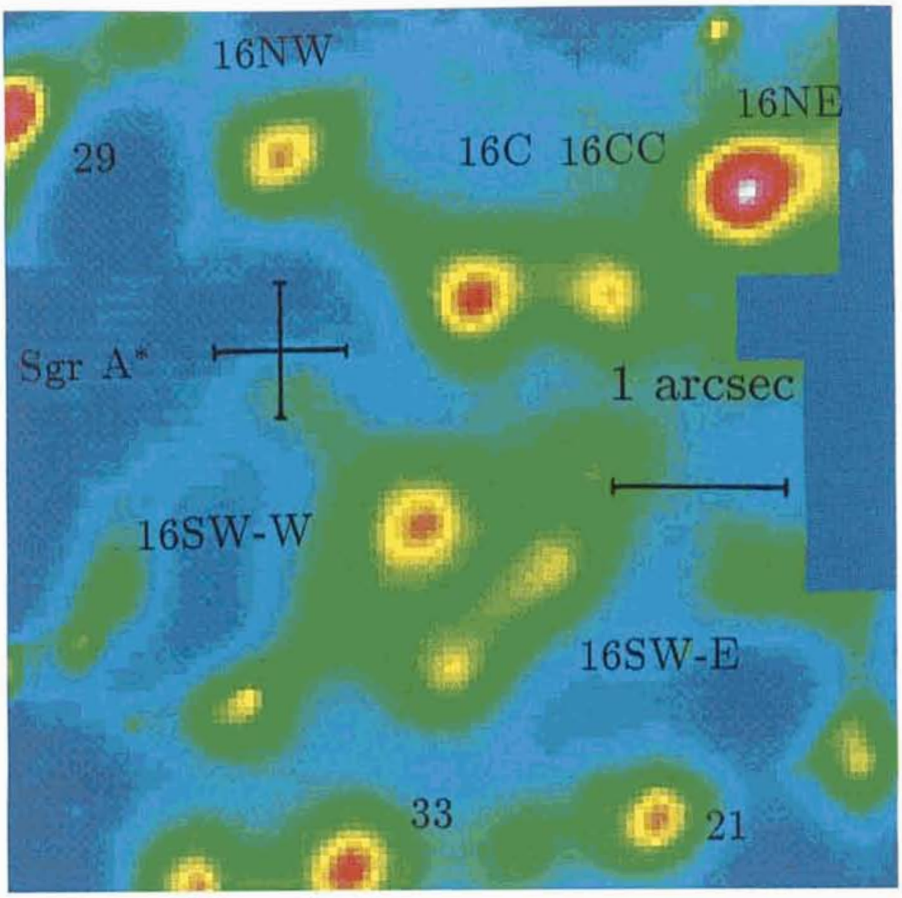
The GALACTIC CENTRE: Best Images Ever

First Results from SHARP at the NTT

A. ECKART, R. HOFMANN, P. DUHOUX, R. GENZEL, S. DRAPATZ, MPE, Garching bei München

At the Max-Planck-Institut für Extraterrestrische Physik a System for High Angular Resolution Pictures, SHARP, has been developed during the last 18 months for observations in the near infrared spectral range (1 to 2.5 μm). It is based on a 256 × 256 HgCdTe NICMOS3 array manufactured by Rockwell Inc. The camera has an image scale of 0.05 arcsec/pixel at the Nasmyth focus of the ESO 3.5-m New Technology Telescope. The electronics and the data acquisition system allow the recording of frame rates up to 10 Hz for speckle observations with a built-in cold shutter. Appropriate software has been developed for on-line quick-look data reduction (long exposure, shift-and-add, etc.). The system sensitivity at 1 Hz data rate allows 5σ detection of K ≈ 9.5 in ≈ 1 arcsec seeing and fainter for better seeing.

The first observing run took place between August 18 and 23, 1991. The figure shows a K-band image of the inner region of the galactic centre (6.4 × 6.4 arcsec corresponding to 0.25 × 0.25 pc, North is up and East to the right; a scale of 1 arcsec is marked). The image is a result of ≈ 1000 frames with 0.5 sec and 1 sec exposure time



per image using the shift-and-add method and ten iterations of the Lucy image sharpening algorithm. The average instantaneous seeing was of the order of 0.4 arcsec and the resulting final resolution in the image is ≈ 0.25 arcsec. In the combination of spatial resolution and sensitivity this image by far surpasses anything available till now. The basic new results on the structure of the near infrared emission of the central 0.25 parsec of the Galaxy emerge already at this early stage of analysis.

First, the IRS16 complex is resolved into about 15 compact sources, most of which may be hot massive stars. Identifications are marked in the figure. Second, we find from repeated exposures a K ≈ 12.5 object within ≈ 0.2 arcsec of the radio source SgrA*, whose location and positional uncertainty are marked by the cross in the figure. This source may represent the long sought-for infrared counterpart of the compact radio source.

We would like to thank the ESO Director General for his vision to admit SHARP at the NTT and the ESO staff at Garching and on La Silla for their excellent professional support and enthusiastic commitment.

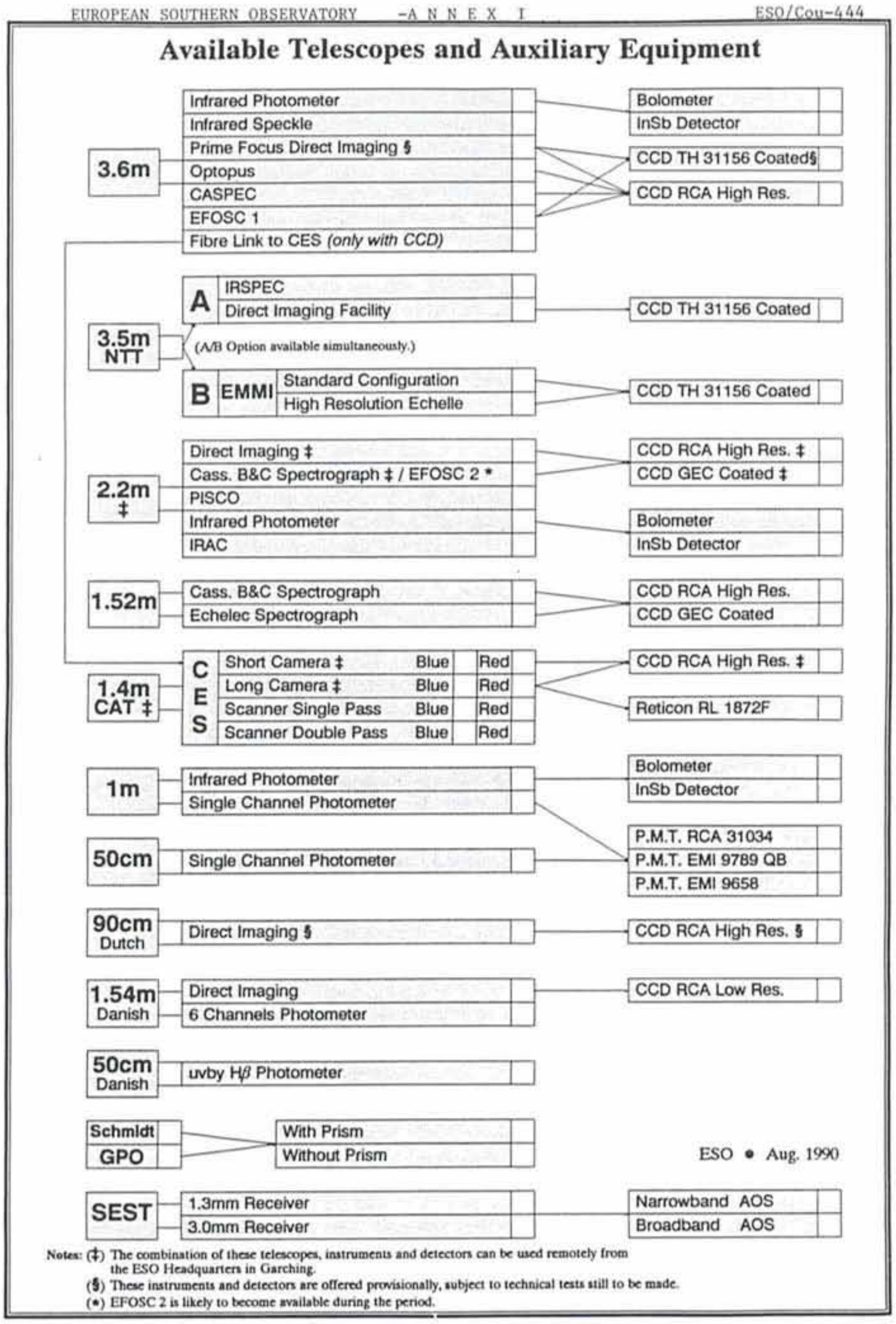
Will La Silla Succumb to the VLT?

S. CRISTIANI, University of Padova, Italy

Concern has spread around the ESO community about the future of La Silla. Seeing the great technical efforts required by the VLT, some people fear that, according to the law of "man-power conservation", the efforts at La Silla will be correspondingly reduced, causing in due time a deterioration of its present quality and diversity. Is this apprehension based on real-life experience or rather on expectations?

An informal round-table discussion took place at La Silla on this subject in mid-August 1991. E. Cappellaro, B. Fort, P. Véron and myself were invited to discuss with the Director General, D. Hofstadt and J. Melnick the fundaments of these apprehensions. If negative or positive changes were noted in the last three, four years, since the VLT decision, what are the major concerns and how can the community safeguard La Silla?

The discussion started with an analysis of the present situation on the mountain, trying to single out its weak points on the basis of the outcome of the Users Committee Meeting held last May. A general consensus expressed concern about the present status of detectors, both optical and infrared, some of which appear to be out of date. The causes of this relatively negative situation were ascribed to the rather large number of CCDs now in operation at La Silla, probably more than at any other observatory in the world, and into the difficulty, at least till a few years ago, of getting modern IR detectors, due to export licence problems. The Director General, responding to a somewhat pessimistic view of P. Véron and B. Fort about the rate of improvement, promised that major efforts will be spent at the ESO Headquarters to replace as fast as possible the bad detectors; in the IR in particular, a Rockwell 256×256 array



that is believed to be one of the best on the market, will be ready at the telescope early next year. Asked by the Director General about the willingness of some European institutes to contribute to a series of standardized CCD cameras for ESO, B. Fort gave a positive answer.

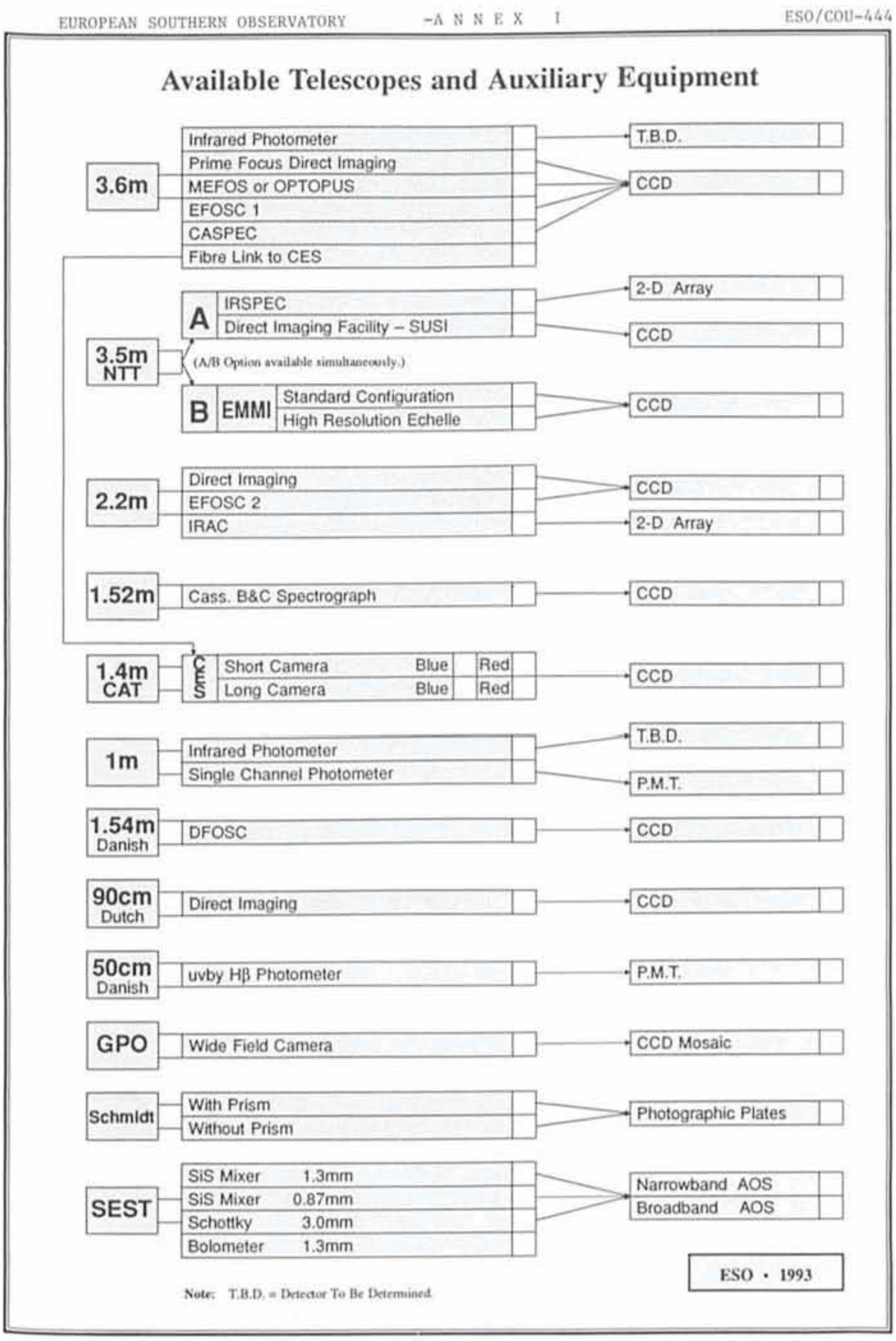
The coming into operation of the NTT has been unanimously reported as a small-scale example of the impact the VLT might have on La Silla operations. In particular, D. Hofstadt lamented the underestimation of the amount of work required at La Silla to make this new telescope ready for common users: three years of heavy work have been necessary. In general it has to be carefully considered that whenever an instrument has been finished in Garching and is delivered at the telescope, a non-negligible amount of work is still required at the Chilean site to take care of all those more or less important details which have been overlooked.

Some of those present noted that the NTT has also absorbed part of the resources of the Astronomy Support Department, and this has resulted in less assistance at telescopes like the 1.5-m Danish or the 2.2-m.

Due to the pressure of the VLT project, the Director General reported 24 positions at La Silla will be phased out of the existing 140 over the next two and a half years. This reduction will affect proportionally the various departments and, to maintain and improve the La Silla standards, a process of "streamlining" will be necessary. An important part of the staff will be moved to Santiago, in the Vitacura premises, with the aim of reducing the number of people on the mountain and to economically support both La Silla and VLT Observatories in the future.

Tentative Time-table of Council Sessions and Committee Meetings until end of 1991

November 11–12:	Scientific Technical Committee
November 14–15:	Finance Committee
November 28–29:	Observing Programmes Committee
December 2– 6:	Council, in Chile



Fewer people on the mountain imply less board and lodging, less transport, fewer administrative requirements, allowing some economies. This of course involves a certain amount of simplification of La Silla: telescopes, like the Bochum and perhaps the ESO 50-cm, will be closed, the number of instrument change-overs will be reduced, the scheduled runs will become longer. Less direct assistance to the astronomers will necessarily imply the preparation of better and more detailed telescope and instrument manuals.

D. Hofstadt illustrated the upgrades already taking place or planned for the next years: the 1.5-m Danish adapter will be renewed; the 90-cm Dutch has a new adapter and a CCD camera; IRAC will be upgraded; the prime focus at the 3.6-m is available for direct imaging (which could then be removed from the 2.2-m); the fibre spectrograph MEFOS will also be installed at the 3.6-m. A possible evolution of the telescopes and auxiliary equipment from now to 1993 and 1996 is shown in three ESO menus (see Figures), according to a document presented by the Director General to the Council. These are illustrations, not, as yet, decisions.[1]

However, the simplification of the La Silla instrumentation, as remarked by E. Cappellaro, is a very delicate process, especially when the final decisions about the various instruments have to be taken. Many people, for example, would be upset if the B&C spectrograph, the only one allowing certain investigations of galaxy dynamics, is removed from the 2.2-m, others will cry if CASPEC is confined to the ESO 1.5-m, and even J. Melnick disagrees with D.

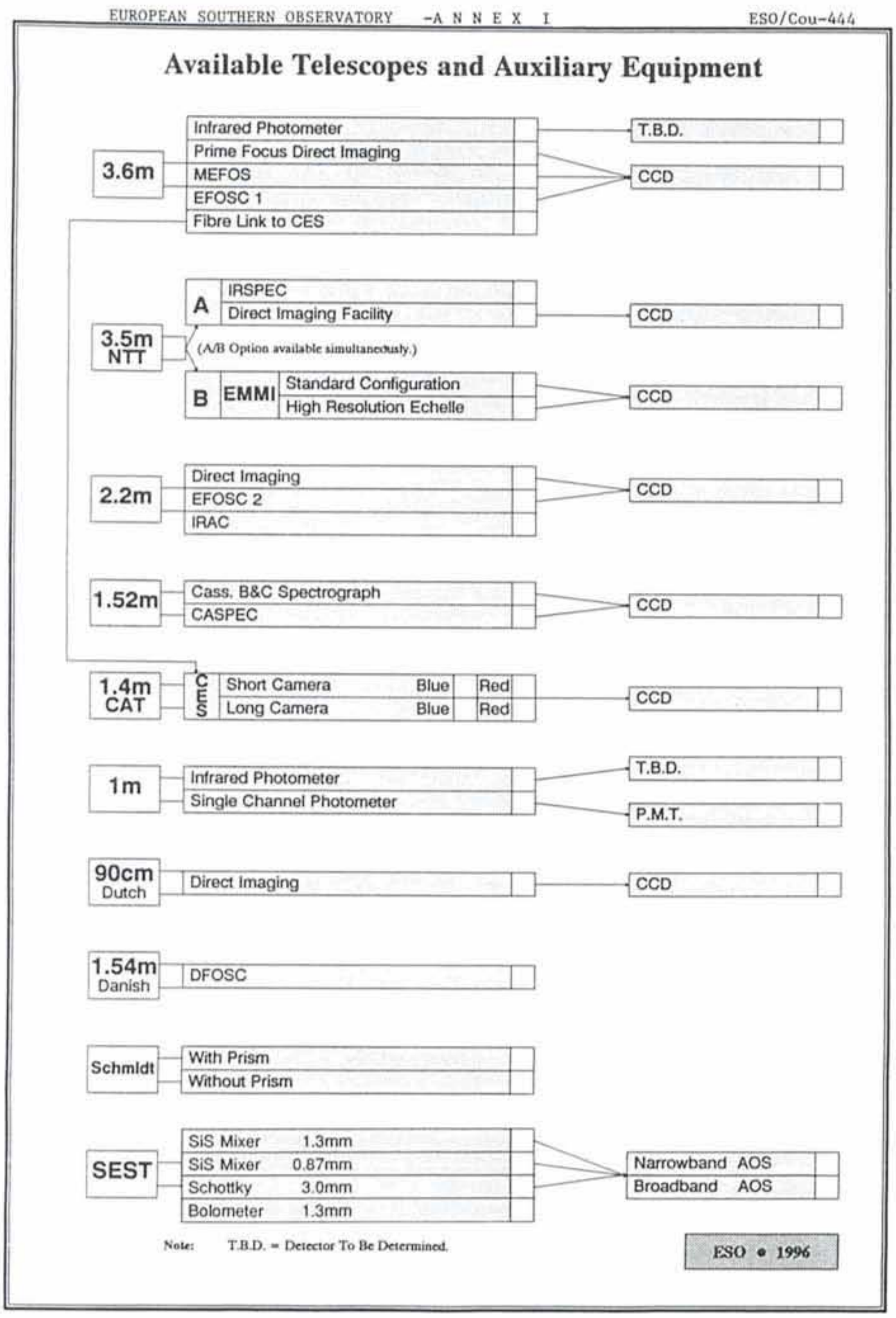
[1] Readers/ESO users are reminded that suggestions and comments are welcome and may influence ESO decisions. Please direct your communications to the Director General.

Hofstadt about removing the direct imaging facility at the 2.2-m. It is obvious that a larger involvement of the community of users in these decisions must be ensured. The importance of playing a leading role in large-scale digitized surveys of the sky was emphasized, to avoid to be confined to a secondary place as may have happened with the ESO Schmidt compared to the UK Schmidt. The DG replied that in this respect the scientific pressure of the ESO astronomers will be the driving factor.

B. Fort suggested that some work on the upgrading of the instruments could be carried out by institutes in Europe. This received a positive echo by the Director General, who explained that the examples of MEFOS and TIMMI are illustrative in this sense and that the main limitations from the ESO side are related to manpower rather than to money. A general consensus was expressed about the importance of transmitting the experience gained in the VLT design to La Silla and to ensure a strong coupling of this project with the La Silla management. The VLT standards will become the La Silla standards: ethernet, VME, UNIX, MIDAS, VxWorks. The people of the VLT project will spend a considerable fraction of their time in Chile: having many short duty trips would simply not work in the case of the VLT, and this will allow the interchange of precious experience.

Finally, concerns were expressed about the future of MIDAS, the standard image-processing system at the telescopes in the VLT era. As remarked also in the Users Committee last May, although there is a general satisfaction with its improvements, the progress of MIDAS is considered slow compared to IRAF. This fact together with the improvement of reduction facilities at the home institutes, is the probable cause of the decrease in the number of astronomers coming to Garching to use the ESO facilities. The Director General explained that it is not ESO's intention to compete with the much larger manpower available for the development of IRAF/STSDAS. MIDAS will be offered as built-in-house software for off-line reductions of data acquired with ESO telescopes and, with the same core, but with different and more user-friendly interfaces, as data acquisition software. MIDAS is coming into La Silla telescopes' control rooms!

This was more or less the point reached when the round table had to cede to an incipient clear observing night. I hope that the reader could get from this incomplete report enough material to answer the primitive question indicated by the title of this contribution.



Visiting Astronomers

(October 1, 1991 – April 1, 1992)

Observing time has now been allocated for Period 48 (October 1, 1991 – April 1, 1992). As usual, the demand for telescope time was much greater than the time actually available.

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

3.6-m Telescope

Oct. 1991: Mazure et al. (1-014-43K), La Franca/Hawkins/Véron/Andreani, Vettolani et al. (1-019-47K), Crane/Mandolesi/Palazzi/Wampler, Spite F./Spite M./François, Lennon/Kudritzki/Groth/Gabler, Groth/Kudritzki/Lennon/Humphreys, Testor/Schild.

Nov. 1991: Macchetto/Turnshek/Sparks, Danziger et al. (6-003-45K), Shaver/Böhringer/Ebeling, Miley et al. (2-001-43K), Warren/Iovino/Shaver, Warren/Hewett, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Habing et al. (7-008-47K), Gouiffes/Ögelman/Augusteijn Chincarini/Buzzoni/Molinari/Cavanna.

Dec. 1991: Soucail/D'Odorico/Fort/Altieri/Mellier, Lorenz H./Mücket/Müller/Doroshkevich, Giraud/Ellis/Infante/Nottale, Marano/Cimatti/Mignoli/Zitelli/Zamorani, Møller/Warren, Dennefeld/Bertin/Boulanger/Moshir, De Boer et al. (3-003-43K) – Wolf, Gratton, De Boer et al. (3-003-43K) – Molaro, Anton/Seifert.

Jan. 1992: Beuermann/Trümper/Thomas/Reinsch/Simon, De Boer et al. (3-003-43K), Azzopardi, Hensberge et al. (5-005-45K), Schwarz, Hünsch/Reimers/Toussaint, Habing et al. (7-008-47K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Gouiffes/Ögelman/Augusteijn, Balkowski/Kraan-Korteweg/Cayatte.

Feb. 1992: Rasmussen PK/Jørgensen I/Franx, Turatto et al. (4-004-45K), Danziger et al. (6-003-45K), Wisotzki/Groote/ Reimers, Hamann/Wessolowski/Koesterke, Reimers et al. (2-009-45K), Reimers et al. (2-009-45K), Caulet/Danks/Woodgate, Böhringer/Ebeling/Pierre/Voges/Horstmann/ Schuecker/Seitter/Cruddace/Kowalski/Wallin/Collins.

March 1992: Böhringer/Ebeling/Pierre/Voges/Horstmann/Schuecker/Seitter/Cruddace/Kowalski/Walling/Collins, Danziger et al. (6-003-45K), Vigroux/Vader, Hes/Fosbury/Barthel, Gouiffes/Ögelman/Augusteijn, Molaro/Bonifacio/Castelli/Pasquini, Mundt/Eislöffel/Neckel, Habing et al. (7-008-47K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Boulesteix/Coradi/Amram/Le Coarer.

New Central Computer Facilities at ESO

The central computer facility at ESO Headquarters, a cluster of two VAX 8600 systems running the VAX/VMS operating system, will be replaced in the fall of 1991. After extensive benchmarking and evaluations of a wide range of UNIX systems, ESO has purchased two Solbourne 5E/802i machines, 40 MHz SPARC technology, running the UNIX operating system. They are compatible with SUN systems and offer a symmetric multiprocessor architecture with high I/O-bandwidth. The machines were purchased from Kontron, Eching near Munich.

In the course of September the machines will be made operational, whereas at the same time the support of both VAX 8600 machines will be scaled down with an anticipated removal in early November. Two VAX 3100 servers will be purchased to ensure a minimum VAX/VMS support for the user community. However, they will not be available for major computational tasks. Visitors who intend to use ESO computing facilities for data reduction and analysis are advised to discuss this issue with the Visiting Astronomers Section when they reserve time.

ESO can be contacted through electronic mail using either one of the following host names on the networks, EARN: DGAESO51, SPAN: ESO, EUNET: eso. uucp, and Internet: eso. org. The VAX/VMS dependent PSI-mail will be discontinued. For E-mail purposes, default account names consisting of the first initial and the last name (truncated to 8 characters) will be normally available. It will still be possible to get interactive access through either modem (300/1200/2400 baud), X.25, Internet or SPAN.

3.5-m NTT

Oct. 1991: Azzopardi/Breysacher/Lequeux, Bergvall/Rönnback, Gilmozzi/Griffiths/Danziger/Tolstoy, Saglia/Colless/Dunn, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette, Habing et al. (7-008-47K), Käufl/Rosa/Viegas, De Boer et al. (3-003-43K) – Spite, Dubath/Mayor/Queloz.

Nov. 1991: Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette, De Lapparent et al. (1-003-43K), Giallongo/Buson/Cristiani/Trevese, Bignami et al. (6-002-45K), Miley et al. (2-001-43K), Surdej et al. (2-003-43K), Butcher/van Rossum, Andersen M.I./Andersen J./Jørgensen U.G., Nieto/Fraix-Burnet/Poulain/Bender/Surma, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette.

Dec. 1991: Held/Mould, Tarenghi/D'Odorico/Wampler/Peterson/Yoshii/Silk, Møller/Shaver/Warren/Hes/Padovani, De Boer et al. (3-003-43K) – Dennefeld, Miley/Griffiths/Tolstoy, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, De Boer et al. (3-003-43K) – Dennefeld, Lagrange-Henri/Beust/Beuzit/Deleuil/Gry/Ferlet/Vidal-Madjar, Heydari-Malayeri, Cappellaro/Capaccioli/Held/Ferrario.

Jan. 1992: Cappellaro/Capacciolo/Held/Ferrario, Fort et al. (1-015-45K), Reipurth, Surdej et al. (2-003-43K), Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Danziger/Moorwood/Oliva, Werner/Dreizler/Heber/Hunger/Rausch, Schönberner/Napiwotzki/Jordan.

Feb. 1992: Schwarz/Corradi/Sahai, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Tammann et al. (1-022-47K), Bergeron et al. (1-012-43K) Wampler et al. (2-010-45K), Hamann/ Wessolowski/Koesterke, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Møller/Shaver/Warren/Hes/Padovani, Tammann et al. (1-022-47K), Peterson /D'Odorico/Tarenghi/Wampler/Yoshii/Silk.

March 1992: Peterson/D'Odorico/Tarenghi/Wampler/Yoshii/Silk, Surdej et al. (2-003-43K), Carollo/Danziger, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, Turatto et al. (4-004-45K), Tammann et al. (1-022-47K), Habing et al. (7-008-47K), Fosbury/Moorwood/Oliva/Tsvetanov/Hes, Lagerkvist/Williams/Dahlgren/Fitzsimmons/Magnusson, Smette/Surdej/Shaver/Foltz, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle.

2.2-m Telescope

Oct. 1991: Westerlund/Azzopardi/Rebeirot/Breysacher, Breysacher/Azzopardi/Lequeux/Stasinska/Westerlund, Turatto et al. (4-004-45K), Jarvis/Sackett, Barbieri et al. (2-007-43K), Vidal-Madjar/Arlot/Beust/Colas/Deleuil/Ferlet/Gry/Lagrange-Henri/Sevre, Cristiani/Miller/Goldschmidt.

Nov. 1991: Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Meylan/Dubath/Mayor, Miley et al. (2-001-43K), Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Surdej et al. (2-003-43K), Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Courvoisier/-Blecha/Bouchet/Maraschi/Wagner, Boisson/Joly/Moorwood/Oliva/Ward, Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Courvoisier/Blecha/Bouchet/Maraschi/Wagner, De Boer et al. (3-003-43K) – Koornneef, Andersen M.I./Andersen J./Jørgensen U.G., Habing et al. (7-008-47K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Piotto/Capacciolo/Ortolani, Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Courvoisier/Blecha/Bouchet/Maraschi/Wagner.

Dec. 1991: Courvoisier/Blecha/Bouchet/Maraschi/Wagner, Turatto et al. (4-004-45K), Bertola/Rix/Zeilinger, Zeilinger/Bertola, Dennefeld/Bertin/Boulanger/Moshir, Chiosi/Bertelli/Bressan/Ortolani/Vallenari, De Boer et al. (3-003-43K) Seggewiss, MPI TIME.

Jan. 1992: MPI TIME, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Habing et al. (7-008-47K), Waelkens/Van Winckel, Persi/Tapia/Roth/Origlia/Ferrari-Toniolo, Lin Yun/Clemens/Santos, Lin Yun/Clemens/Santos, Waelkens/Van Winckel, Turatto et al. (4-004-45K).

Feb. 1992: Danziger et al. (6-003-45K), Bertola et al. (1-008-43K), Jarvis/Sackett, Reimers et al. (2-009-45K), Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Caulet/Käufl, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Sabbadin/Cappellaro/Turatto/Benetti/Salvadori, Surdej et al. (2-003-43K).

March 1992: Capacciolo/Piotto/Corradi, Infante/Melnick/Lucey/Terlevich/Lahav/Lynden-Bell, Capacciolo/Piotto/Corradi, Carollo/Danziger, Covino/Palazzi/Penprase/Schwarz/Terranegra, Cox/Moneti/Bronfman/Deharveng, Courvoisier/Bouchet/Blecha/Orr/Valtaoja, Habing et al. (7-008-47K), Fosbury/Di Serego Alighieri/Prasad/Tadhunter, Spaenhauer/Labhardt, Turatto et al. (4-004-45K).

1.5-m Spectrographic Telescope

Oct. 1991: Danziger/Matteucci/Zeilinger/Carollo/Buson, Bertola/Amico/Zeilinger, Barbieri et al. (2-007-43K), Goudfrooij/De Jong T./Jørgensen H.E./Nørgaard-Nielsen/Hansen/van den Hoek, Testor, Ramella/ Da Costa/Focardi/Geller/Nonino.

Nov. 1991: Ramella/Da Costa/Focardi/Geller/Nonino, Testor, Caon/Capaccioli/Ferrario, Gerbaldi et al. (5-004-43K), Danziger et al. (6-003-45K).

Dec. 1991: Bianchini/Della Valle/Ögelman/Orio/Bianchi, Dejonghe/Zeilinger, Rampazzo/Prugniel/Sulentic/Bica, De Ruiter/Lub, Schöneich/Zelwanowa/Khokhlova, Courvoisier/Bouchet/Blecha, Beuermann/Trümper/Thomas/Reinsch/Simon.

Jan. 1992: Epchtein/Guglielmo/Le Bertre/Fouqué/Kerschbaum/Hron, Paturel et al. (1-017-45K), Ballereau/Chauville/Zorec, Bässgen/Diesch/Grewing, Rasmussen P.K./Jørgensen I./Franx, Zeilinger/Stiavelli/Møller.

Feb. 1992: Zeilinger/Stiavelli/Møller, Proust/Mazure/Capelato/Sodré, Danziger et al. (6-003-45K), Gerbaldi et al. (5-004-43K), Drechsel/Lorenz R./Mayer, Acker/Cuisinier/Köppen/Rolla/Stasinska/Testor.

March 1992: Acker/Cuisinier/Köppen/Rolla/Stasinska/Testor, Mennickent/Vogt, Calvani/Acosta-Pulido/Marziani, Courvoisier/Bouchet/Blecha, Mürset/Schmid, Thé/De Winter, Claudi/Bianchini/Ginocchietti/Friedjung.

1.4-m CAT

Oct. 1991: Da Silva/de la Reza, Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Nussbaumer/Schmutz/Schmid, Ferlet/Hobbs/Wallerstein, Barbuy/Hetem, Pasquini.

Nov. 1991: Pasquini, Štefl/Balona, Kürster/Schmitt/Hatzes, Foing/Collier-Cameron/Ehrenfreund/Jankov/Bruston.

Dec. 1991: Foing/Collier-Cameron/Ehrenfreund/Jankov/Bruston, Danks/Massa/Crane, Ferlet/Beust/Deleuil/Gry/Lagrange-Henri/Vidal-Madjar, Ferlet/Hobbs/Wallerstein, Lagrange-Henri/Beust/Deleuil/Ferlet/Foing/Gosset/Gry/Vidal-Madjar, Diesch/Bässgen/Grewing.

Jan. 1992: Diesch/Bässgen/Grewing, Nussbaumer/Schmutz/Schmid, Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Hummel/Hanuschik/Dachs, Sterken/Jerzykiewicz/Pigulski, Toussaint/Reimers/Hansen/Hünsch, Westerlund, Kürster/Schmitt/Hatzes, van der Bliek/Waters/Trams/Habing, Kürster/Schmitt/Hatzes.

Feb. 1992: Kürster/Schmitt/Hatzes, Gredel, Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Cayrel de Strobel, Vincent/Hackman/Hubrig/Launhardt/Piskunov/Saar/Tuominen/Ryabchikova, Ferlet/Hobbs/Wallerstein, Lagrange-Henri/Beust/Deleuil/Ferlet/Foing/Gosset/Gry/Vidal-Madjar, Randich/Pallavicini, Vreux/Gosset/Hutsemekers.

March 1992: Vreux/Gosset/Hutsemekers, Gehren/Axer/Fuhrmann/Reile, Vreux/Gosset/Hutsemekers, Nussbaumer/Schmutz/Schmid, Toussaint/Reimers/Hansen/Hünsch, Pottasch/Sahu K.C. Covino/Palazzi/Penprase/Schwarz/Terranegra, Hummel/Hanuschik/Dachs, Lenhart/Grewing.

1-m Photometric Telescope

Oct. 1991: Gieren/Moffett/Barnes, Barbieri et al. (2-007-43K), Catalano F.A./Leone/Kroll, Prugniel/Rampazzo/Combes/Sulentic.

Nov. 1991: Prugniel/Rampazzo/Combes/Sulentic, Zickgraf/Wolf, Foing/Collier-Cameron/Ehrenfreund/Jankov/Bruston.

Dec. 1991: Rampazzo/Prugniel/Combes/Sulentic, Beust/Lagrange-Henri/Ferlet/Char/Deleuil, Gieren/Moffett/Barnes.

Jan. 1992: Gieren/Moffett/Barnes, Richtler, Courvoisier/Bouchet/Blecha, Lorenzetti/Liseau/Spinoglio, Lépine/Ortiz/Fouqué/Epchtein, Courvoisier/Bouchet/Blecha.

Feb. 1992: Manfroid/Gosset, Fulchignoni/Barucci/Coradini/Burchi.

March 1992: Fulchignoni/Barucci/Coradini/Burchi, Di Martino/Mottola/Gonano/Neukum, Pottasch/Manchado/García-Lario/Sahu K.C., Courvoisier/Bouchet/Blecha, Thé/De Winter, Hainaut/Dental/Pospieszalska-Surdej/Schils/Surdej/West.

50-cm ESO Photometric Telescope

Oct. 1991: Mantegazza/Antonello/Poretti, Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Kohoutek.

Nov. 1991: Kohoutek/Zickgraf/Wolf, Gochermann/Grothues.

Dec. 1991: Gochermann/Grothues, Schober.

Jan. 1992: Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Surdej/Detal/Hainaut/Pospieszalska-Surdej/Schils.

Feb. 1992: Surdej/Dental/Hainaut/Pospieszalska-Surdej/Schils, Char/Jankov/Foing/Neff/Fernández/Maldini/Galleguillos/Berrios, Cutispoto/Leto/Giampapa/Pagano/Pasquini, Drechsel/Lorenz R./Mayer.

March 1992: Drechsel/Lorenz R./Mayer, Thé/De Winter, Hainaut/Dental/Pospieszalska-Surdej/Surdey/West.

GPO 40-cm Astrograph

Nov. 1991: Elst.

Dec. 1991: Vidal-Madjar et al.

1.5-m Danish Telescope

Oct. 1991: West/Lamy/Sekanina/Grün/Keller, Surdej et al. (2-003-43K), Barbieri et al. (2-007-43K), Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Lamy/Sekanina/Grün/Keller, Bergvall/Rönnback, West/Lamy/Sekanina/Grün/Keller, Surdej et al. (2-003-43K), Freudling/Da Costa/Giovanelli/Haynes/Salzer/Wegner, Lindgren/Ardeberg/Lundström, Tagliaferri/Mayor/Cutispoto/Pallavicini/Pasquini, Mayor et al. (5-001-43K), West et al., Pagel/Schmidt.

Nov. 1991: West et al., Pagel/Schmidt, Imbert/Maurice, Martin/Maurice, Mantegazza/Ferro, Gammelgaard/Kristensen.

Dec. 1991: West/Lamy/Sekanina/Grün/Keller, Surdej et al. (2-003-43K), Hes/Prugniel/Rampazzo/Amram, Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Lamy/Sekanina/Grün/Keller, Jørgensen H.E./Hansen/Nørgaard-Nielsen, Vidal-Madjar et al., West/Lamy/Sekanina/Grün/Keller, Surdej et al. (2-003-43K), Jønch-Sørensen, Knude, Jørgensen/Rasmussen, Reipurth/Lindgren/Mayor, Andersen/Nordström et al.

Jan. 1992: Tagliaferri/Mayor/Cutispoto/Pallavicini/Pasquini, Mayor et al. (5-001-43K), Duquennoy/Mayor, West/Hainaut/Marsden/Smette, Surdej et al. (2-003-43K), Heidt/Wagner.

Feb. 1992: Danziger/Bouchet/Gouiffes/Lucy/Fransson/Mazzali/Della Valle, West/Hainaut/Marsden/Smette, Rickman/Lindgren M./Tancredi/Kamél, West/Hainaut/Marsden/Smette, Surdej et al. (2-003-43K), Richter/Capaccioli/Ferrario/Thänert, West/Hainaut/Marsden/Smette, Surdej et al. (2-003-43K), Mayor et al. (5-001-43K), Jønch-Sørensen/Knude, Reipurth/Lindgren/Mayor, Nordström/Andersen, Florentin/Surdej et al.

March 1992: Ardeberg/Lindgren/Lundström, Danziger/Bouchet/Gouiffes/Lucy/Fransson/ Mazzali/Della Valle, Surdej et al. (2-003-43K), Augusteijn/van Paradijs/van der Klis, Surdej et al. (2-003-43K).

50-cm Danish Telescope

Oct. 1991: Group for Long Term Photometry of Variables.

Nov. 1991: Group for Long Term Photometry of Variables, Štefl/Balona, Group for Long Term Photometry of Variables, Štefl/Balona, Chevreton/Schneider/Roques/Sicardy.

Dec. 1991: Chevreton/Schneider/Roques/Sicardy, Gosset/Manfroid/Vreux/Smette, Jønch-Sørensen/Knude, Sterken/Jerzykiewicz/Pigulski.

Jan. 1992: Sterken/Jerzykiewicz/Pigulski, Maitzen/Hensberge/Catalano F.A./Leone, Group for Long Term Photometry of Variables.

Feb. 1992: Group for Long Term Photometry of Variables. Manfroid/Gosset/Vreux, Jønch-Sørensen/Knude.

March 1992: Jønch-Sørensen/Knude, Ardeberg/Lindgren/Lundström.

90-cm Dutch Telescope

Oct. 1991: Mazure/Katgert/Dubath/Focardi/Gerbal/Guiricin/Jones/Lefèvre/Molès, Oblak et al.

Nov. 1991: Foing/Collier-Cameron/Ehrenfreund/Jankov/Bruston, Van Dessel/Sinachopoulos.

Dec. 1991: Van Dessel/Sinachopoulos, De Ruiter/Lub, Alcaino/Liller/Alvarado/Wenderoth, Prugniel/Rampazzo/Sulentic.

Jan. 1992: Prugniel/Rampazzo/Sulentic, Hünsch/Reimers/Toussaint.

Feb. 1992: Oblak et al., Ferrari/Bucciarelli/Massone/Koornneef/Lasker/Le Poole/Postman/Siciliano/Lattanzi.

March 1992: Ferrari/Bucciarelli/Massone/Koornneef/Lasker/Le Poole/Postman, Siciliana/Lattanzi, Schramm, Schwarz/Van Winckel, Augusteijn/van Paradijs/van der Klis.

SEST

Nov. 1991: Tacconi, Krügel, Loiseau, Andreani, van Moorsel, Sage, Bouchet, Danziger, Gredel, Henning, Cox.

Jan. 1992: van Dishoeck, Combes, van der Hulst, Cameron, Bouchet, Danziger, Kastner, Omont, Israel.

March 1992: Sage, Bouchet, Danziger, Crane, Stark, Wilson, Winnberg, Wild, Reipurth, Omont, Forveille.

PROFILE OF A KEY PROGRAMME:

A Survey of Nearby Clusters of Galaxies

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1. Introduction

Detailed analysis of the structure of a large sample (well representative of all richness and morphological classes) of rich clusters of galaxies may provide several constraints for theories of the formation of large-scale structure on scales of the order of a few Mpc.

Since the overall relaxation time of a cluster is larger than the Hubble time, it could be expected that present-day clusters are at best partially relaxed – a situation which could be revealed by the presence of subclustering.

The convincing detection of dynamically significant substructure in clusters may put severe constraints on the scenarios of formation and on the shape of the initial fluctuation spectrum. However, this detection, as well as dynamical analysis, requires a large number (at least 100) redshifts per cluster.

Peculiar velocities of clusters with respect to the Hubble flow could in principle reveal the characteristics of the mass distribution on larger scales (such as the inter-cluster distance). The Cold Dark Matter Scenario, however, does not predict large-scale peculiar velocities with respect to the Hubble flow for rich clusters. It therefore appears desirable to confirm e.g. in the Southern galactic hemisphere the large-scale peculiar motions which have been claimed to exist (Bahcall et al., 1986) but questioned by other authors. Again, this requires a suitable sample and several redshifts per cluster.

2. Definition of an Observational Programme

The preceding motivations have led us to design an observational programme which has been accepted by ESO as a Key Programme. We have thus selected a sample of clusters of galaxies from the revised and South extended Abell catalogue (Abell, Corwin and Olowin, 1989); the sample can actually be divided into two subsamples since the selection has been performed following two different criteria. On the one side we needed a set of clusters sufficiently rich to allow a meaningful structural and dynamical analysis, possibly covering almost equally all Bautz-Morgan morphological types and having a redshift of $\cong 0.05$. This last requirement ensures that we explore several core radii and cover a sufficiently large range of magnitudes on a field of 30 arcmin (Optopus field). We found 30 clusters (the so-called "structure" clusters) satisfying all these requirements. On the other side, we selected 100 clusters (the "peculiar" clusters) which are expected to form a complete sample up to $z=0.1$ in the Southern galactic hemisphere. This large subsample will be used to map and analyse the large-scale peculiar motion field. There is a partial overlap (12 objects) among the two subsamples, giving a total of 118 clusters for the whole sample. We plan to obtain spectroscopy and photometry for about 150 members of the "structure" clusters and 30 to 50 members of the "peculiar" ones. Spectroscopy is being obtained by using the OPTOPUS instrument at the ESO 3.60-m, whilst CCD photometry (Danish 1.54-m) is required in order to calibrate our photographic one.

For each selected cluster, catalogues of galaxies have been obtained by scanning photographic plates (glass copies of the red PSS for the northern clusters and film copies of the SRC survey for the southern ones) using the Leiden ASTROSCAN plate-measuring machine. Objects are selected around the cluster centre within several Abell radii. The typical size of a scanning region is about one square degree for "peculiar-motion cluster" and 4 square degrees for "structure" ones. By setting a threshold value (typically at 5 times the sky noise above the background) a list of objects is then produced. For each object the following final parameters are kept: (i) the centre of gravity position, (ii) a photometric parameter, the logarithm of which is in good approximation a linear function of magnitude, (iii) the second moment of the density distribution, which is a measure of the size of the image, and (iv) the number of image pixels which have a photographic density above the detection threshold. Star-galaxy separation is performed by plotting: second moment of the density ver-

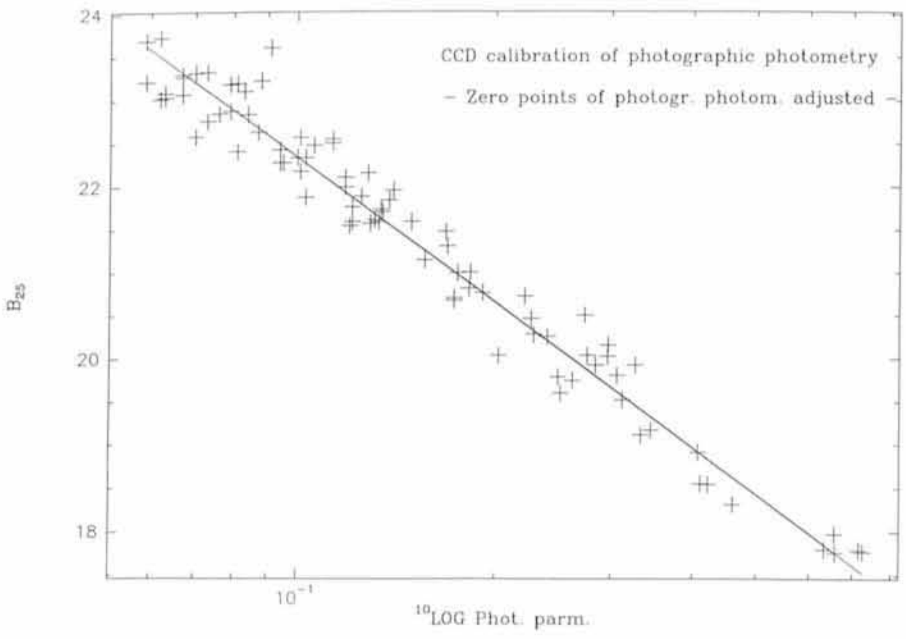

Figure 1: *Photometric parameter versus B magnitudes for the combined data. Straight line corresponds to the best fit.*

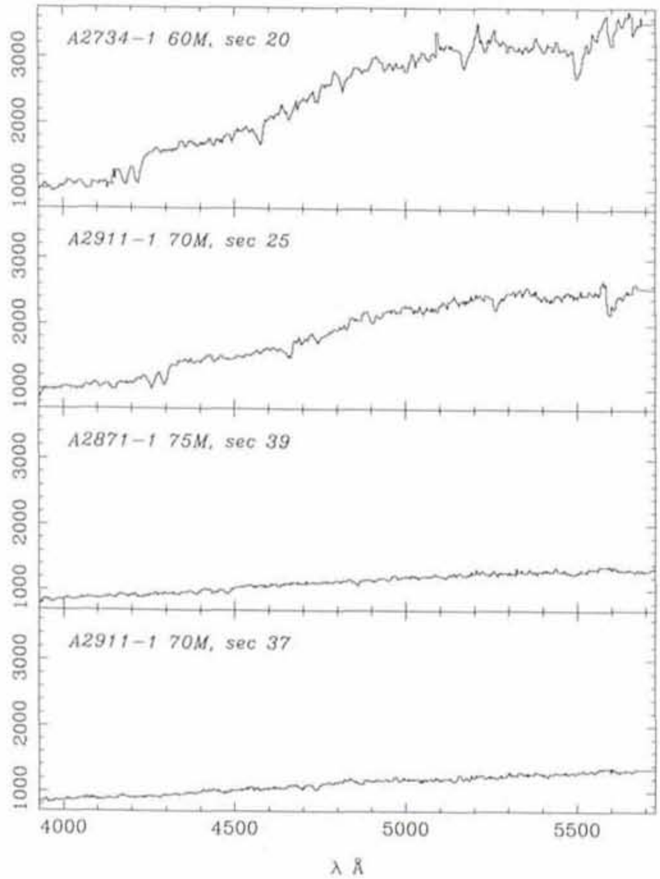

Figure 2: *Four calibrated spectra of decreasing quality.*

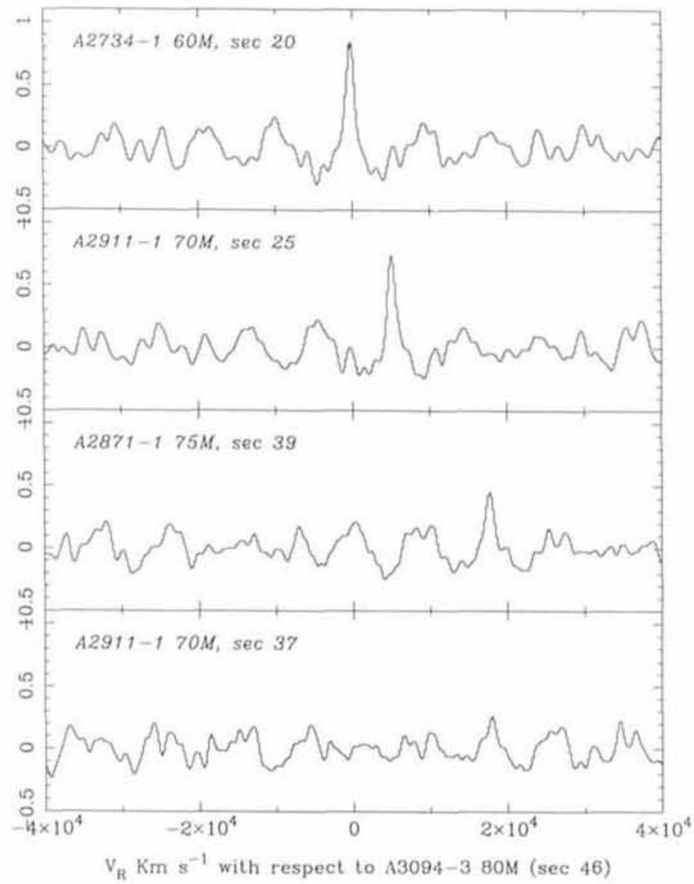

Figure 3: *Correlation function peaks for the spectra of Figure 2 using a bright galaxy of our sample as template.*

sus photometric parameter. The stars' locus is well defined and separated from the galaxy one. Anyway, unresolved double stars and bright saturated galaxies can fall in unproper positions. Visual inspection of the candidate galaxies and of the bright stars is performed in order to avoid misclassification.

The final catalogues are then used to produce OPTOPUS files in order to punch the plates (30 and then 50 fibers/plate) for each OPTOPUS run.

3. Observations and Reduction

So far, observations were made in September and October 1989, March and April 1990 and September and October 1990 both for spectroscopy (3.6-m+OPTOPUS) and CCD photometry (1.54-m Danish).

CCD photometry is being performed in order to calibrate our photographic photometry.

For this purpose, CCD frames have been taken for each OPTOPUS field, covering the largest possible range in magnitudes so as to minimize errors in the calibration. CCD frames are taken in both B and R colours, exposure times being typically of 15 min in B and 5 min in R. Several standard stars and secondary fields were also observed during the night. Photometric observing runs suffered partial bad weather or bad conditions (seeing of about 4 arcsec in October 1989) and technical problems (pointing was lost several times due to computer crash) leading however to a reliable bulk of data, but on a smaller than expected number of objects. These CCD data have been processed using the IRAF package and a faint galaxy photometry package (Lefevre et al., 1986) installed on SUN workstations at CFHT. The reduction yields photometric parameters (positions, ellipticities, R_{25}, B_{25}...) for several hundred of galaxies. These B and R magnitudes were then used in order to calibrate the photometric parameter P produced by ASTROSCAN. Taking into account the relative magnitude offset from plate to plate, a linear relation between B_{25} and log P was fitted to the combined data (goodness of fit 0.98) and shown in Figure 1. From this picture, it turns out that the dispersion in the correlation between photographic and CCD magnitudes is of about 0.25 magnitudes and that the limiting magnitude of our spectroscopic survey is about $B_{25}=21$.

The OPTOPUS multifiber instrument coupled with Boller and Chivens spectrograph has been used at typical resolutions of about 10 Å and spectral range between 3900 and 5900 Å. Since March 1990 the spectroscopic efficiency has been greatly increased thanks to a new optical configuration, an increased number of fibers (50 instead of 30) and the possibility of plugging the fibers in the plate at the desk of the observing room during the previous exposure acquisition. More recently (October 1990) the availability of the new Tektronik CCD detector, having a much lower read-out noise, gave another significant improvement at the system overall efficiency making OPTOPUS a real "industrial-era" z-machine.

Spectroscopic data reduction, which includes fibers extraction, wavelength calibration, continuum removal and cross correlation, has been performed by means of FIGARO routines, well suited for our aim, installed in Granada and Montpellier on Vax stations. Wavelength to pixel solution is obtained on a long arc (20 mn), exposure of an He-Ne lamp taken at the beginning of each night so as to ensure a high S/N even of faint features. Relative shift is computed and applied on each subsequent arc frame. Arc frames were taken both before and after the cluster exposure to minimize errors induced by mechanical flexures of the instrument which turn out anyway to be negligible.

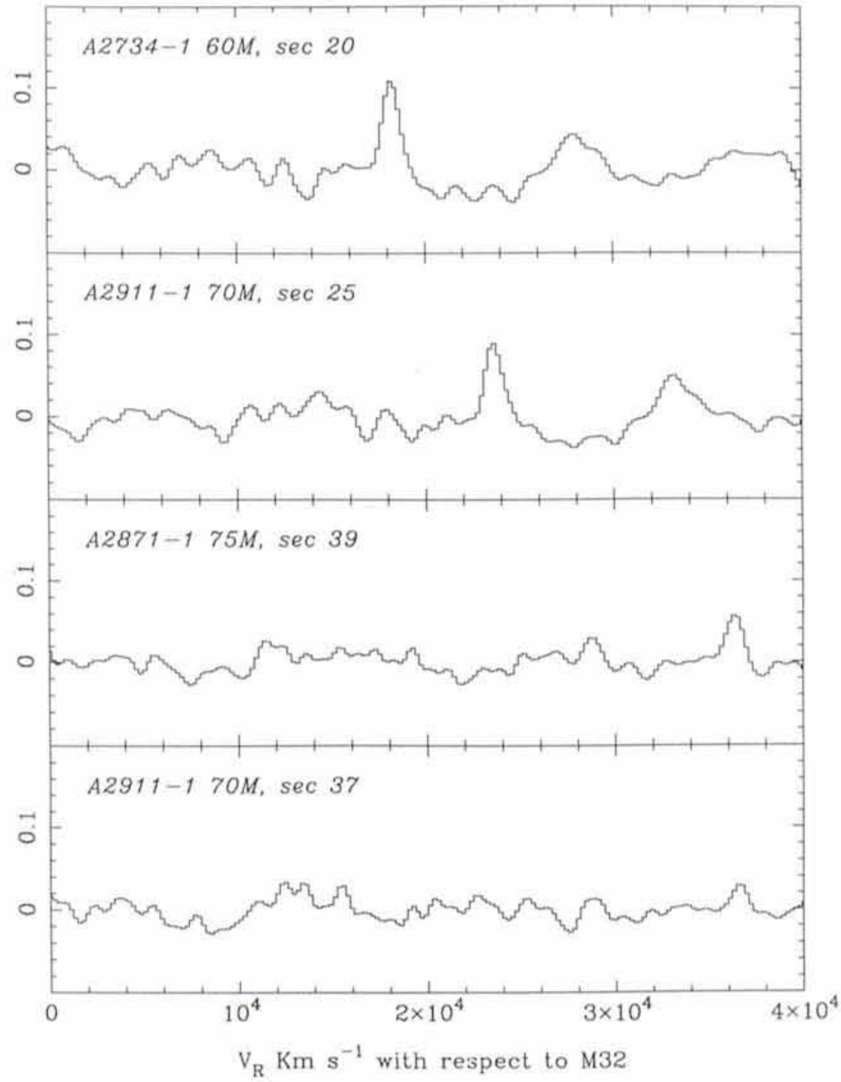

Figure 4: *Correlation function peaks for the spectra of Figure 2 using M32 as template.*

The wavelength solution obtained by a 3rd order polynomial fit to our data leads to a typical rms per frame of 0.08 to 0.1 Å (maximum value being about 0.3, 0.4 Å). To illustrate the quality of our data, a set of wavelength calibrated spectra of decreasing quality is shown in Figure 2. The redshifts were then determined by cross-correlation technique. We found that best results are obtained using as template a galaxy spectrum belonging to our sample and having a high S/N, as can be seen by comparing Figures 3 and 4, which show the correlation peaks obtained correlating the spectra of Figure 2 with a bright galaxy belonging to our sample and with a standard velocity template (M32). The zero point can be subsequently determined by cross-correlating the galaxy template with a few well-known velocity objects (like e.g. M32, NGC 4111) of which we got spectra with different instruments. So far, about 3,000 spectra have been collected. The efficiency (number of actually determined velocities/number of spectra) has increased from about 60% (the first runs) to about 85% (the last ones) due to better set-up and a more efficient acquisition device leading presently to about 2,000 measured velocities. All these data have been reduced and a histogram of radial velocity for the whole sample is shown in Figure 5. It can be seen that the data are peaked at $z = 0.05$ as we may expect due to our selection criteria. The errors on the velocities are obtained following Tonry and Davis pre-

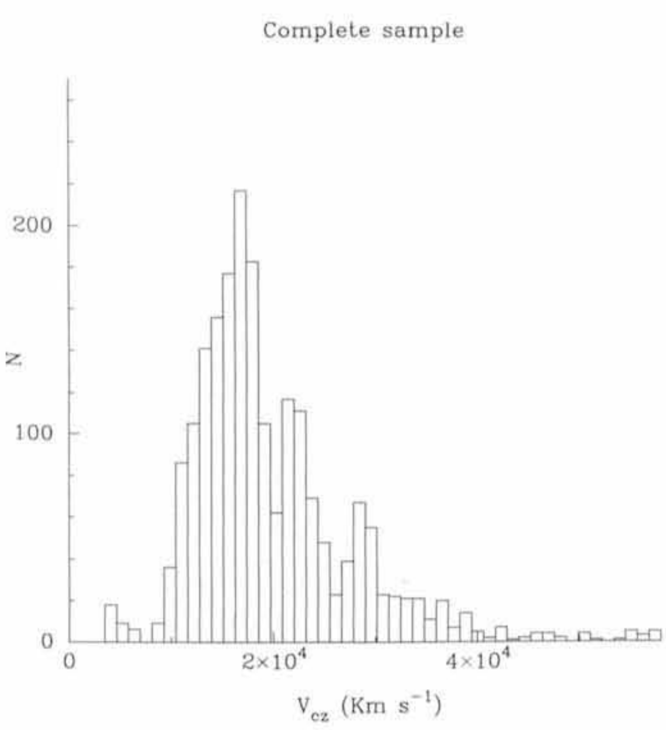

Figure 5: *Histogram of the velocities for the presently available data.*

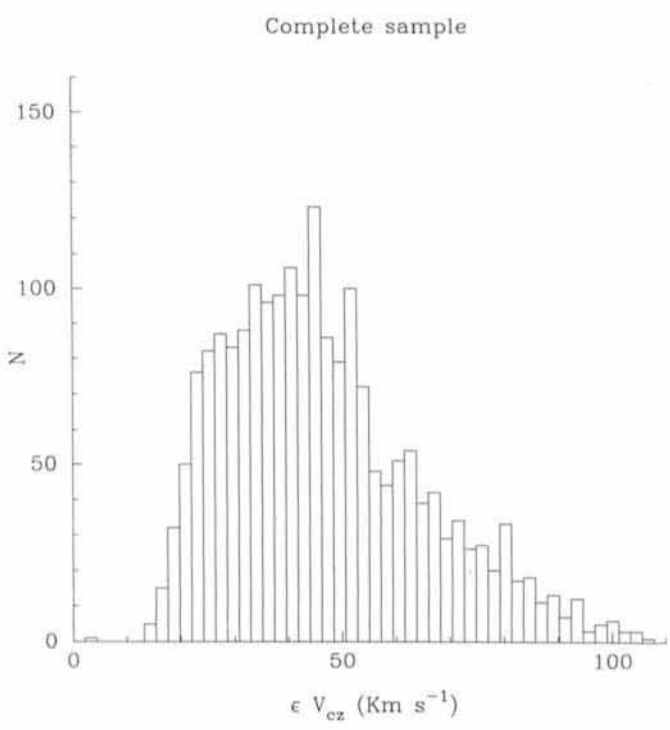

Figure 6: *Distribution of the errors in the velocities for the presently available data.*

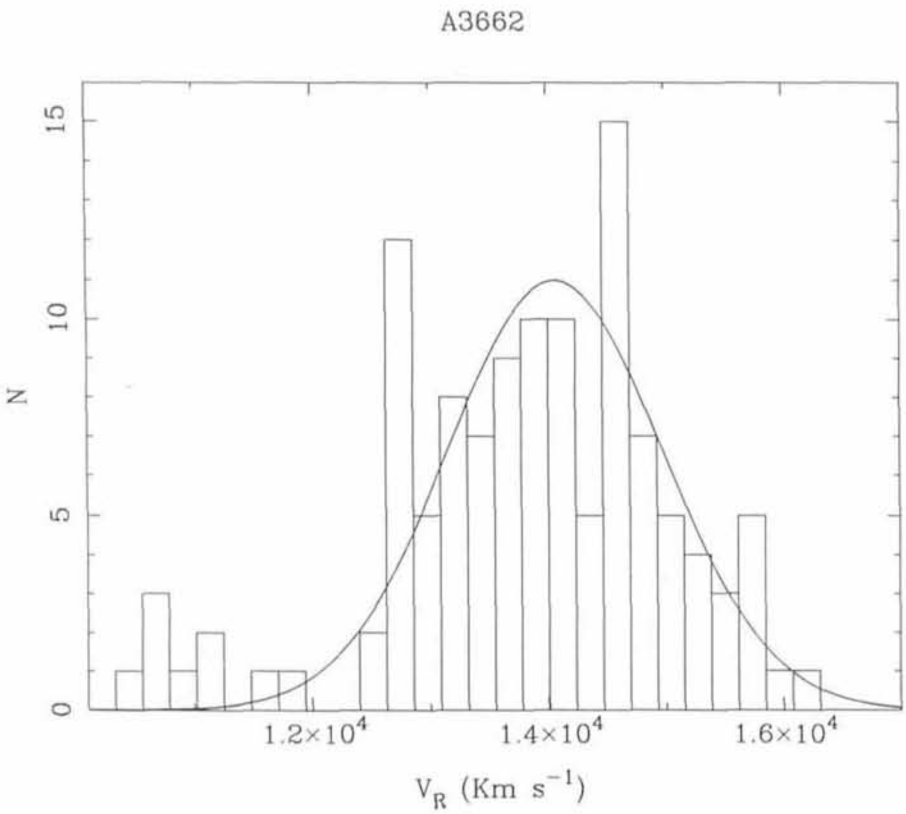

Figure 7: *Distribution of the velocities obtained in one field of the cluster A3662; a gaussian fit is superimposed.*

scriptions (1979); we get a typical value of 40 km/sec as can be seen in Figure 6 in which the histogram of the errors for all the available data is shown. It should be noted that the large scatter is due to a substantial improvement of the error value which decreased from about 60 km/sec for the first runs to about 30 km/sec due to the increased S/N of the last-run spectra. Comparison to external data is under progress. Finally, in Figure 7 we show the distribution of velocities obtained in one field of the cluster A 3662; this is a "structure" cluster, that is a cluster on which we plan to perform detailed dynamical analysis. More data are thus going to be acquired, nevertheless, even from this single field we can suspect the presence of a complex structure (two peaks?). Further data will allow a check on the reality of this feature.

In conclusion, the aim of our project is to give new results both on the structure and dynamics of clusters of galaxies and on their peculiar motions with respect to the Hubble flow. For these reasons we have drawn a composite sample of more than 100 clusters, for which we plan to collect a large bulk of spectroscopic and photometric data. The Optopus multi-fiber instrument is particularly well suited to our aim. It would not have been possible to design such a large project without a large amount of granted telescope time as it is in the philosophy of the ESO Key Programmes.

References

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Bahcall, Soneira, *Ap. J.*, **311**, 15, 1986.

Lefevre, Bijaoui, Mathez, Picat, Lelievre, *Astron. Astroph.*, **154**, 92, 1986.

Tonry, Davis, *Astron. J.*, **84**, 1511, 1979.

A Progress Report on the VLT Instrumentation Plan

S. D'ODORICO, J. BECKERS and A. MOORWOOD, ESO

1. The VLT Instrumentation Plan

The Very Large Telescope of the European Southern Observatory is the most ambitious project in the history of ground-based optical-infrared astronomy. With its four 8-m telescopes to be operated as separate units and in a combined mode and the associated array of smaller telescopes for interferometry it represents a unique technical and managerial challenge. Within the overall project, the procurement, installation and operation of a set of instruments at the different foci of the array are in itself an effort much larger than anything done in the past at ESO or at any other observatory. At the same time it is crucial to achieve the scientific goals of the project. For this reason the definition and procurement of the first-generation instruments was tackled very early in the project schedule. In June 1989, ESO elaborated and distributed widely in the community a Preliminary Instrumentation Plan which was based on recommendations by the VLT Working Groups, set up to give advice on the scientific use of the VLT, and technical work carried out at ESO. Based on the responses and comments to this Plan, ESO prepared a revised version which was adopted by the Scientific and Technical Committee in March 1990. This Instrumentation Plan now includes ten instruments and two replicas and a tentative schedule for their implementation at the VLT. Some of the instruments are relatively well defined, for others preparatory work is under way to arrive at a complete set of specifications. A review article on the VLT instruments has been published in the *Journal of Optics* (1991) Vol. **22**, p. 85. Excluded from this plan is the instrumentation to be designed for the VLT Interferometer. Figure 1 shows the mechanical structure of the unit telescope and the foci positions and Table 1 lists the various instruments with their assigned location. The complement of instruments at the first two telescopes can be considered as relatively frozen but the information on the last two telescopes is indicative and might be updated as the project evolves.

A cornerstone of the VLT Instrumentation Plan is the participation of institutes in the ESO member countries in the construction of most of the instruments. This is a major departure from the current situation which sees the quasi-totality of the installed ESO instruments to be the result of internal development. The new approach is dic-

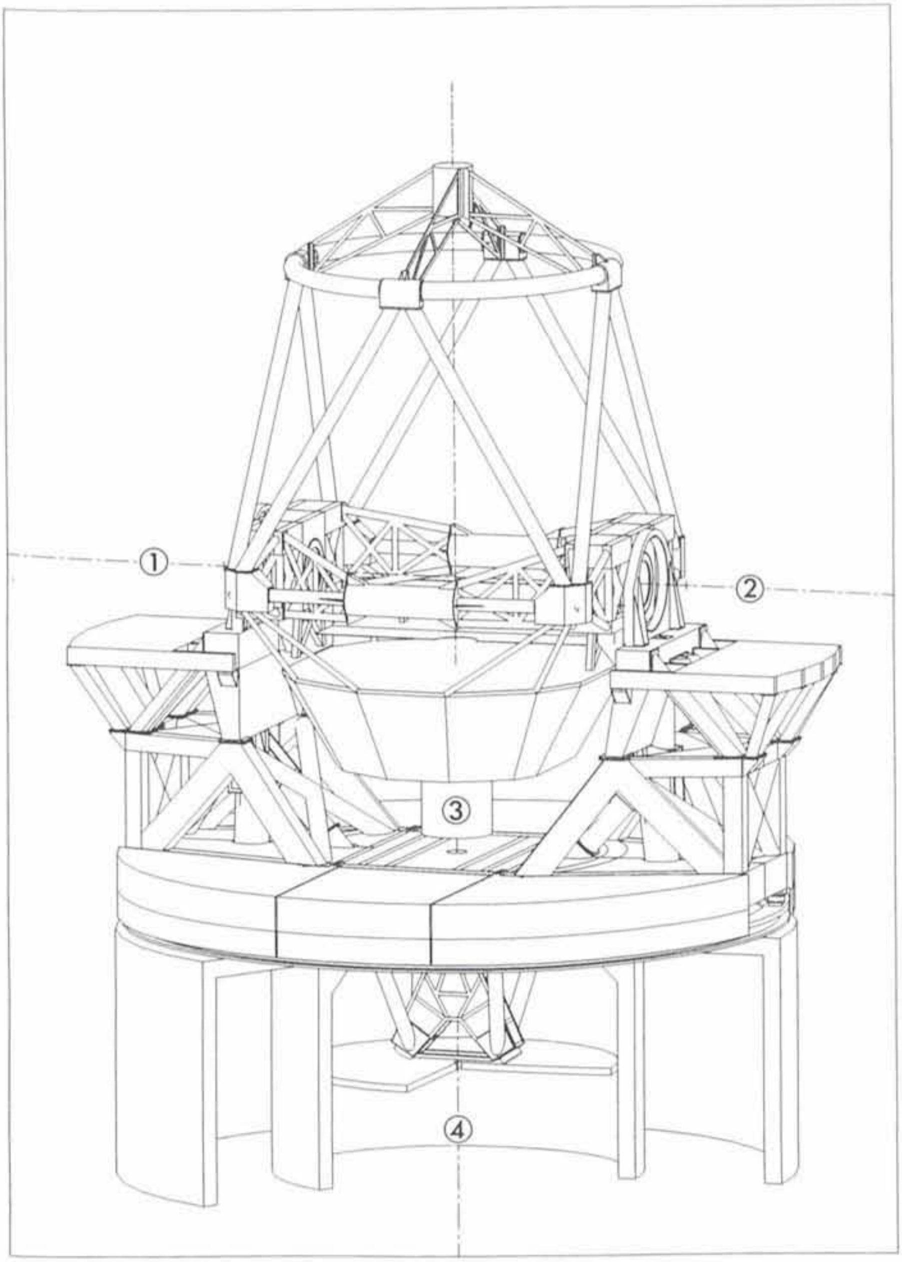

Figure 1: *Tridimensional view of the mechanical structure of the 8-m unit telescope showing the positions of the Nasmyth (1 and 2), Cassegrain (3) and coudé (4) foci.*

tated by the need to fully involve the community in the VLT and at the same time to overcome the limitations on manpower and budget. Only about 10 % of the total VLT financial resources is reserved for instrumentation, even if it is this VLT component which at the end sets the quality and the variety of the scientific results to be obtained by the facility. To use the financial resources in an optimal way, ESO expects to pay for the instrument components to be procured from industry while the institutes will contribute with their expertise, manpower and free use of their facilities. Beside this general guideline, the mechanism of selection of institutes to be associated with the instrument projects is going to be adapted to the characteristics of the single instrument under consideration, such as the degree of definition of the specifications, the amount of expertise in that specific field existing in the community and the time available for the project. Clearly, ESO has to exercise in all cases at tight control on the quality, the costs and the development schedule to make sure that the VLT Instrumentation Plan fully meets its scientific goals and is realized in time and within budget.

In the following paragraphs, we present a short résumé of the status of the different instruments and of the future actions. The VLT Instrumentation effort at ESO is organized by Jacques Beckers (Diffraction Limited and Interferometric Instrumentation), Sandro D'Odorico (Optical Instrumentation) and A. Moorwood (Infrared Instrumentation).

2. Status of the Instrument Projects

2.1 Medium-Resolution IR Spectrometer/Imager

This is one of the two instruments in the Plan to be realized under the direct responsibility of ESO and will be the first major instrument to be installed at the VLT. It will provide for direct imaging at different scales and long slit spectroscopy over the 1-5 μm wavelength range and it is scheduled to be installed at one of the Nasmyth foci of the first unit telescope during the second half of 1996. The Infrared Instrumentation Group is currently finalizing its detailed Technical Specification and a Preliminary Design and Implementation Plan for both internal review and presentation to the Scientific and Technical Committee in November of this year.

2.2 UV-Visual Focal Reducer/Spectrographs

The operation modes of this instrument, to be built in two copies for the Cassegrain foci of the first and the third unit telescope, are similar to those of the two EFOSC instruments in operation at La Silla. Additional features will include a multislit unit and optics for polarimetry observations. A Call for Proposals for the Design, Construction and Installation of the two copies was distributed in May 1990. Two Proposals were received, one from a consortium of the Observatories of Toulouse, Roden and Trieste and the other from a consortium of the Observatories of Heidelberg, Munich and Göttingen. Both proposals being of excellent technical quality, at the end of the reviewing process the German consortium was selected because their offer presents a very significant financial advantage. The contract negotiations are now under way and the project work is planned to start officially in the last quarter of this year. Its schedule calls for an installation of the first copy of the instrument at the UT1 at the end of 1996.

2.3 Near-IR High-Resolution Imaging Camera

This is the first instrument to make use of the individual coudé foci of the VLT and its associated adaptive optics. Its goal is to do diffraction-limited imaging and low-resolution spectroscopy in the 1- to 5-micron wavelength region. It will do that either directly at the longer wavelengths, with or without adaptive optics, or, at the shorter wavelengths, with the aid of image reconstruction algorithms developed in speckle interferometry. The Call for Proposals for this instrument distributed in May 1990 listed only the required capabilities. It left the detailed design up to the proposers. This resulted in two very different proposed instrument realizations, one based on an all-mirror design, the other including lenses. The latter, proposed by a consortium of the Max Planck Institutes for Astronomy (Heidelberg) and Extraterrestrial Physics (Garching) together with the Observatory of Turin was selected after a thorough evaluation. Its schedule calls for installation on the first VLT telescope in 1997.

TABLE 1. ***Complement of Instruments for the VLT***

Medium-Resolution IR Spectrometer/Imager	Nasmyth, UT 1
UV-Visual Focal Reducer/Spectrograph No. 1	Cassegrain, UT 1
Near-IR High-Resolution Imaging Camera	Coudé, UT 1
UV-Visual Echelle Spectrograph No. 1	Nasmyth, UT 2
Visible Speckle Camera	Coudé, UT 2
Mid-IR Imager/Spectrometer	Cassegrain, UT 2
Multi-fibre Area Spectrograph	Nasmyth, UT 3
UV-Visual Focal Reducer/Spectrograph No. 2	Cassegrain, UT 3
UV-Visual Echelle Spectrograph No. 2	Nasmyth, UT 3
Multichannel FTS	Nasmyth, UT 4
High-Resolution/Visible Spectrograph	Combined
High-Resolution/Infrared Echelle Spectrograph	Combined

2.4 UV-Visual Echelle Spectrograph

This is the other instrument to be built under direct responsibility of ESO. At least two identical copies will be built for installation at two Nasmyth foci of two unit telescopes. Based on the concept included in the VLT Instrumentation Plan, the instrument design aims at a very high efficiency and at a maximum resolving power of 40,000. Studies of the various subsystems are now under way with the goal to complete a Predesign Report and an Implementation Plan by April 1992 for internal review and presentation to the Scientific and Technical Committee.

2.5 Multi-Fibre Area Spectrograph

The Focal Reducer/Spectrographs to be built for the Cassegrain foci of the VLT are designed to do multiobject spectroscopy over a field of 7 × 5 arcmin approximately. The Multi-Fibre Spectrograph will be designed to gather and guide the light of objects distributed over the larger field of view of the Nasmyth focus (30 arcminutes diameter approximately) to the slit of a stationary medium-resolution spectrograph. The area spectroscopy option of the same instrument shall be designed to provide spectroscopic data over a 2D array of points covering an area of the sky at a resolution corresponding to the best seeing conditions at the telescope. In the studies which led to the definition of the VLT Instrumentation Plan, the scientific objectives of this type of instrument were not discussed in any detail and hence the technical requirements such as e.g. the number of fibres and the optimal spectroscopic resolution are not defined. To fill this gap, ESO has distributed at the end of July 1991 (see insert on this page) a Call for Proposals for a Definition Study and a Predesign of the instrument. The results of the study will be used for the final specifications of the manufacturing contract.

2.6 Visible Speckle Camera

To reach the highest possible, diffraction-limited resolution of the 8-metre telescopes (0.01 arcsec) it is necessary to use the speckle interferometry techniques at visible wavelengths. These have been largely conceived and developed by scientists in the ESO member countries in the last two decades. These techniques have reached a level of maturity which warrants the implementation of a general-user facility. Although initially planned for a VLT Nasmyth focus, the Visible Speckle Camera is now planned for a coudé focus since the gains in sensitivity resulting from partial wavefront correction by the infrared adaptive optics more than offsets the losses due to the extra reflections. A call for Proposals for a Definition Study of this instrument is to be released later this year.

2.7 Mid-IR Imager/Spectrometer

This instrument is destined for the Cassegrain focus of unit telescope 2 where it will provide for direct imaging and spectroscopy in the 8-14 μm and possibly 20 μm atmospheric windows. Because this is a new but growing area of observational astronomy various options, particularly for the spectroscopic mode, are still being studied and a 10 μm camera with limited spectroscopic capabilities (TIMMI) is also being developed in collaboration with the Service d'Astrophysique in Saclay, France, as part of the VLT Preparatory Programme. ESO is currently planning to issue a Preliminary Enquiry early in 1992 with the aim of establishing which Institutes would be interested in participating in the development of this instrument. Depending on the actual response the intention would then be to place a Phase A study contract with an Institute or Consortium to be followed by a Development Contract based on the Phase A results and any relevant feedback from the TIMMI project obtained in the meantime.

2.8 High-Resolution Spectrographs

The Instrumentation Plan presently includes three high-resolution spectrographs: an optical one to be installed at the combined focus, an infrared Multichannel FTS for a Nasmyth focus and a cryogenic infrared echelle spectrograph again for the combined focus, although it seems difficult to retain both of the latter in the basic instrument complement.

Preliminary studies on possible concepts have been carried out, but both the technical data and the scientific requirements are not sufficiently defined to start action on the procurement. In February 1992 (see *The Messenger*

On July 30, 1991 ESO distributed a "Call for Proposals for a Definition Study and Predesign of the Multifibre Area Spectrograph for one Nasmyth Focus of the VLT" to institutes and individuals with a potential interest to contribute to the study. Deadline for the replies is October 31.

The study contract to be granted will have a duration of one year and a predetermined cost.

Information on this Call can be obtained from:
Mr. Gerd Wieland
Contract Procurement Office
ESO-Garching
Telefax (89) 320 7327

No. 64, p. 59) ESO is organizing a workshop focussed on High-Resolution Spectroscopy with the VLT. We expect that the scientific objectives in this area of research and the different technical concepts will be thoroughly reviewed and discussed, opening the way for a decision later in the year.

3. Upgrading the VLT Instrumentation Plan

By the end of 1992, seven instrument projects (with two of them foreseeing the manufacture of a replica) will be in various stages of development. The remaining three will be in a definition phase. The entire VLT programme will then be far advanced and detailed information will be available on cost, schedule and foreseen performance. The time will then be ripe for a critical review of the entire instrumentation plan, an assessment of the resources still available and decisions on additional instruments.

The VLT Adaptive Optics Programme

From April 24 to May 5, 1991, the current configuration of the COME-ON adaptive optics prototype system for the VLT had its last test run before it returned to Europe for a major upgrade.

This 11-night run was devoted to technical tests for adaptive optics and scientific observations. The COME-ON system worked all the time fully reliably and no technical problems occurred. During the run the seeing conditions ranged from excellent to mediocre, and three nights suffered from bad weather conditions.

The technical part of the programme included tests of improved and new software, observations with partial correction at visible wavelengths, and recording of wavefront sequences.

Software with specialized routines depending on the available photon flux allowed an increase of servo-loop bandwidth from 10 to 25 Hz in connection with the intensified Reticon and the electron-bombarded CCD (EBCCD). With the higher bandwidth and improved modal control scheme the diffraction limit of 0.13 arcsec was reached even in the K-Band under good seeing conditions.

In view of partial correction by adaptive optics for speckle and long baseline interferometry, partially corrected images in the visible wavelength range were recorded with an intensified CCD. These recordings will allow a detailed analysis of the image profiles and verification of theoretical predictions for short- and long-exposure images. For these measurements an optical path was installed parallel to the IR camera.

The recorded wavefront sequences will allow to explore the spatial and temporal behaviour of the turbulence-induced atmosperic perturbations and comparisons with the theory of the turbulence.

The scientific objectives of this run included the environment of young stellar objects, asteroids and planets, the search of the potential third component of Sirius A, and luminous blue variables. From the young stellar objects, S CrA is of particular interest. It shows a clear

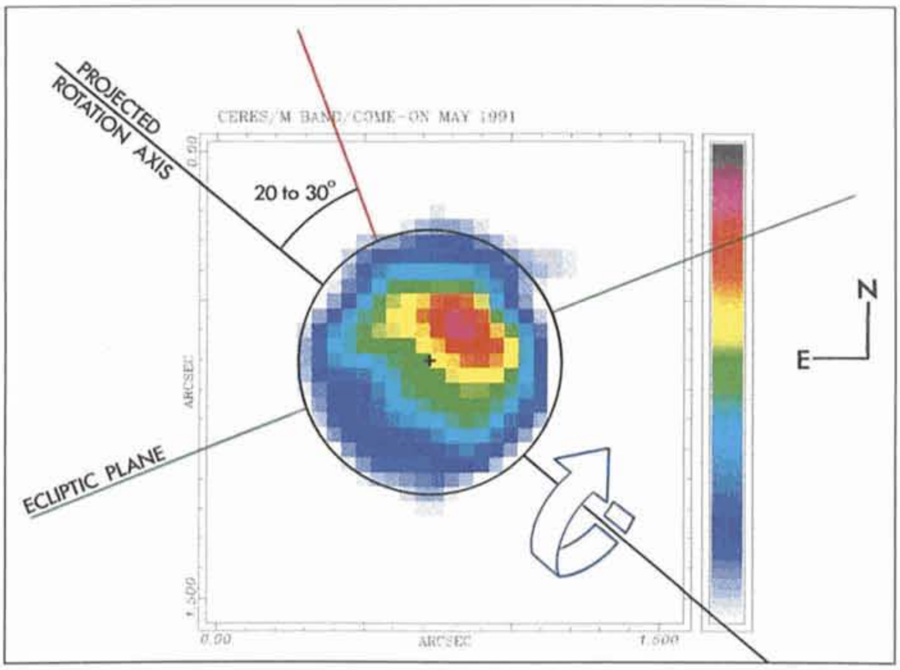

Figure 1: *One of the most impressive results with adaptive optics is the first direct determination of the rotation axis of an asteroid. Ceres was observed on May 5, 1991 with the 3.6-m telescope, using "COME-ON", and a 32×32 IR camera (Meudon). The data are still under reduction. The image shows Ceres at M (4.7 microns). At this wavelength, the reflected solar flux is negligible compared to the thermic emission of the asteroid's surface. Previous speckle observations, confirmed by photometric curves, show that the albedo is constant over the surface. The emission gradient along the S-E/N-W direction is then interpreted as a thermic lag effect of the surface soil, heated by the sun as the asteroid rotates. The rotation axis is found to be inclined 20–30 degrees to the ecliptic pole direction. Courtesy of O. Saint-Pé and M. Combes (Meudon Obs.)*

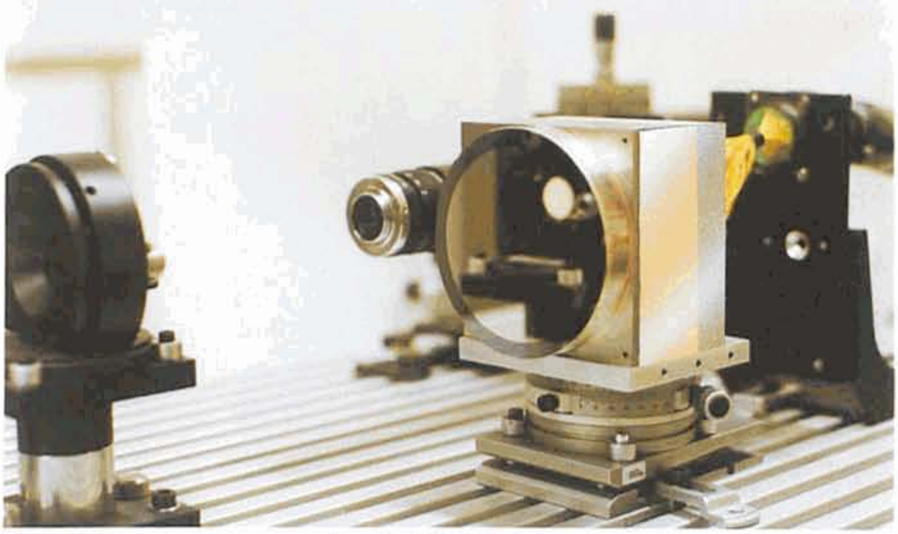

Figure 2: *The new 52-actuator mirror for COME-ON+ during tests at the laboratory of the manufacturer.*

extension. The observations of the asteroid Ceres were exciting and allowed to deduce the rotation axis of that famous small member of our planetary system (see Fig. 1).

Eta Carinae was observed with a CVF and a polarizer. In the K-band, one can recognize hints of the objects observed in the visible range by speckle interferometry, which have a distance of about 0.15 arcsec from the central star. All the scientific observations require a careful data reduction and analysis. The results will be published in the near future.

Immediately after the run the COME-ON system was shipped back to Europe for a major upgrade (COME-ON +). This work will be done at Observatoire de Paris-Meudon under the direction of ONERA. The upgrades include a new deformable mirror from LASERDOT with 52 actuators (see Fig. 2), an improved wavefront sensor and EBCCD provided by LEP (Philips), a faster and more powerful control computer, and some improvements of the passive optical and mechanical components. The upgraded system is scheduled to be back at La Silla in July 1992.

F. MERKLE, N. HUBIN and
G. GEHRING, ESO
F. RIGAUT, Observatoire de
Paris-Meudon

A Report on the SEST Users Meeting and Workshop on Millimetre-Wave Interferometry

22–23 May 1991

The second SEST Users Meeting was held at ESO Garching on Wednesday, 22 May, the first having been held last year at Onsala. In view of the decision to develop the Paranal area for the VLT, it was felt timely to discuss the possibility of a millimetre-wave array in the southern hemisphere, and a workshop on this subject was held on the day following the Users meeting. The combination of these two meetings was obviously popular, as over 60 persons attended.

The SEST Users Meeting

The Users meeting commenced with a number of short reviews illustrating some of the recent scientific results from SEST: The Magellanic Clouds Key Programme (F. Israel and J. Lequeux), CO Rotation Curves of Galaxies (R. Wielebinski), CO in Centaurus A (A. Eckart), Spectral Scans of Sgr B2 (A. Hjalmarsson), Observations of Planetary Nebulae (R. Sahai), and A CO Survey of IRAS Stars (L.-A. Nyman).

These were followed by talks and discussion covering all aspects of the operation and performance of SEST. R. Booth summarized recent developments and future plans, and L.-A. Nyman, N. Whyborn, E. Kreysa, and M. Olberg reviewed specific technical areas, including pointing, holography, receivers (heterodyne and bolometer), spectrometers, observations, calibration, and data reduction. Some of the main discussion points are summarized below.

Telescope pointing remains a matter of concern, and efforts to improve it were outlined. Inclinometers placed on the horizontal part of the fork above the azimuth bearing showed a temperature dependent tilt of the telescope axis amounting to a daily variation of about 6″. First attempts to improve the pointing by including the inclinometer data in the pointing solution are disappointing, giving an improvement in the rms error of only 0.7″. However, these results are very preliminary. The overall pointing rms is still about 3″ in both coordinates. The interferometer telescopes at IRAM show similar axis tilts, so the problem is apparently inherent in the design.

The surface accuracy is another area of concern. Holographic measurements of the SEST reflector surface and its subsequent adjustment led to a significant improvement in the profile (rms 60 micron). However, a subsequent readjustment has increased the error again to around 75 micron. Unfortunately the satellite which has been used as a beacon for the holography measure-

Snow on La Silla!

Heavy snowfall on June 18, 1991 transformed the La Silla Observatory for a few days into a winter landscape. The above photographs were taken on June 20 by Erich Schumann.

ments is no longer available to us, so other measurement techniques are being investigated.

As for receivers, SEST continues to operate with the Schottky systems for both the 100 GHz and 200 GHz bands. The 230 GHz receiver will soon (August) be replaced by an SIS mixer on loan from Smithsonian Astrophysical Observatory. Intermediate frequency amplifiers in both receivers have been replaced by wide (1 GHz) band HEMT amplifiers in an attempt to reduce the noise at the band edges. Another 1 GHz AOS is on order from the University of Köln. This and the purchase of a new frequency synthesizer will facilitate simultaneous observations in both the 100 and 200 GHz bands.

The 350 GHz SIS receiver constructed at Onsala was completed in January and installed on the telescope for tests in April. Unfortunately it has so far proved to be impossible to fabricate SIS junctions of sufficiently small area and hence the noise temperature of the receiver is about 3000K SSB. It is hoped that better junctions will be built in collaboration with the University of Cambridge Metallurgy Department and that the receiver will be installed next year.

The 1-mm bolometer receiver being built in collaboration with the Max-Planck-Institut für Radioastronomie, Bonn, is virtually complete and will be installed on the telescope in late August. This system should then be routinely available and, because of its high sensitivity, should make more pointing sources available.

Particular problems identified at the meeting were pointing jumps (possibly associated with the axis tilt), the need for better receivers at the "work horse" frequencies, and a local oscillator instability which had caused spurious low level wings on narrow lines. The last problem has been fixed but it is important that observers are aware of it. It was suggested that a SEST Bulletin Board should be established in the Garching computer system so that users can be informed about changes and problems.

Suggestions for possible future developments which were discussed included receivers at lower frequencies (<100 GHz), the 150 GHz band, and higher frequencies (410, 460 GHz) VLBI, focal plane imaging arrays, the development of a wobbling secondary, and the (eventual) move of SEST to the Paranal area.

However, for the immediate future it was generally agreed that we should concentrate on improving the pointing and surface of the telescope, and equipping SEST with "state-of-the-art" receivers at 100 and 200 GHz.

Workshop on Millimetre Interferometry

In order to provide suitable background for this subject and bring all participants up to date on relevant developments around the world, this workshop began with reviews on existing millimetre-wave interferometers: The IRAM Interferometer on Plateau de Bure (S. Guilloteau), the Berkeley Interferometer (C. Masson kindly presented a review prepared by J. Welch), the Caltech Millimetre Interferometer (N. Scoville), the Nobeyama Interferometer (K.-I. Morita), and Millimetre VLBI (L.B. Bååth). Planned and proposed developments were then summarized: the Australia Telescope at Millimetre Wavelenghts (L. Staveley-Smith), the Smithsonian Sub-Millimetre Array (C. Masson), plans for interferometry between the JCMT and CSO telescopes (R. Hills), and the NRAO Millimetre Array (R. Brown).

The subject of a possible millimetre array near Paranal was then introduced with three talks on the site and atmospheric conditions. M. Sarazin described the site, and summarized relevant measurements made in the ESO site testing campaign. He showed in particular that the wind, an important parameter for exposed antennas working at high frequencies, appears to be lower in the valleys than on Paranal itself. A. Ardeberg and R. Martin presented results from independent measurements of the water vapour content. While there are differences still to be understood, these two studies both show that the Paranal area is suitable for observations at least to 1 mm.

A lively discussion then followed on the idea of a millimetre-wave interferometer at Paranal, introduced and stimulated by a talk by R. Booth which outlined a possible concept consisting of 10×8 m antennas arranged in an optimum configuration with regard to the equivalent interferometer beam. He considered that such an array could be built for about DM 50M and suggested that we in Europe should consider ways of raising money in order to achieve a useful millimetre array on Paranal as soon as possible.

Various views were expressed by the participants. These ranged from the political through the practical to the ideal scientific concept. A case was made for greater sensitivity, more like that of the proposed US millimetre array which would consist of 40×80 m antennas but will cost at least $ 120M. It was pointed out, however, that none of the existing millimetre arrays is as sensitive as that proposed by Booth and that the southern hemisphere is virgin territory for such an instrument.

There was clear enthusiasm for a southern array. But how could funding be achieved? Could we approach the EEC, or could a consortium from individual countries be put together? In this context, the Japanese plans for a new millimetre array possibly in the southern hemisphere raised the interesting possibility of collaboration with the Japanese astronomers. While no clear answers were forthcoming, the idea that a working group should be set up to consider funding as well as an optimum array design was thought to be a reasonable conclusion of this first meeting on the subject.

P.A. SHAVER, ESO, and
R. BOOTH, Onsala Space Observatory

STAFF MOVEMENTS

Arrivals

Europe

BASBILIR, Mustafa (D), Project Control Manager
ENG, Willem (NL), Administrative Assistant/Invoice Control
GÜNTHER, Peter (DK), Accounting Assistant
HANSEN, Karin (DK), Administrative Clerk (Personnel)
KOEHLER, Bertrand (F), Project Engineer (VLT Interferometry)
PELETIER, Reynier (NL), Fellow
SCHWEMMER, Erika (D), Administrative Clerk (Personnel)
ZIGMANN, François (F), Student

Departures

Europe

BROCATO, Enzo (I), Fellow
DUMOULIN, Bernard (F), Head, Photographic Laboratory
JANSSENS, Lucas (B), Building Project Engineer
LUCY, Leon (GB), Astronomer
OOSTERLOO, Thomas (NL), Fellow
THEUNS, Tom (B), Student

Chile

JARVIS, Brian (AUS), Fellow
SCHUSTER, Hans-Emil (D), Astronomer

Transfers from ESO Headquarters in Garching to VLT Observatory Site in Chile

DE JONGE, Peter (NL), Construction Site Manager
ESCHWEY, Jörg (D), VLT Project Civil Engineer

Impressions from the XXI IAU General Assembly

For the first time in its 72-year history, the International Astronomical Union held its triannual General Assembly in South America. From July 23 to August 1, 1991, about 1200 astronomers from all continents met at the San Martín Centre in Buenos Aires at the River Plate. This was somewhat less than in Baltimore in 1988, but a very respectable number in view of the long travel distance to the Argentinian capital for many of the participants, and certainly sufficient to make this a most memorable and useful meeting. There was a wealth of interesting scientific talks and, as is usual at IAU General Assemblies, much discussion about policy matters of common concern. There were three very well presented Invited Discourses and seven one-day Joint Discussions, in addition to the fully packed programme of the 40 IAU Commissions.

A full report will appear next year in the IAU *Transactions* and *Highlights*. However, for the benefit of those *Messenger* readers who were not present in Buenos Aires, we bring here a small selection of personal impressions, mostly written by participating ESO astronomers. These reports are of course very fragmentary, and it is certainly not possible to do full justice to all the exciting events at such a large meeting. Some of the accounts have been adapted from the excellent daily newspaper, *Cruz del Sur* (see below); the unsigned notes are by the editor.

The Inauguration

The General Assembly was formally opened on July 23 by the President of the IAU, Professor Yoshihide Kozai from Japan. During the immediately preceding Inaugural Ceremony, short speeches were given, several by the organizers and Argentinian dignitaries.

The Chairman of the Local Organizing Committee, Roberto Mendez, was happy to see so many astronomers from all over the world. He was followed by Fernando R. Colomb, his counterpart in the National Organizing Committee, and Esteban Bajaja, President of the Argentine Astronomical Association. Dr. Mendez and his collaborators carried the enormous burden of the successful organization of the General Assembly and all participants owe them a great debt, also in view of the very difficult financial situation under which the preparations were made.

Following a welcome by the Secretary of Education and Culture of the Municipality of Buenos Aires, Osvaldo E. Devries, the President of the Argentinian

Figure 1: *The logo of the 21st IAU General Assembly. The lower part depicts part of an ancient circular pattern showing a nine-pointed star within a double circle of stones. Each star was set upon a platform which was 2 metres high and between 8 and 10 metres in diameter. Fourteen of these platforms have been found in the Argentinian Province of La Rioja; they undoubtedly date back to the La Aguada civilization which flourished in north-west Argentina between 650 and 800 A.D. The circular pattern encloses a diagram that shows the well-known constellation of the Southern Cross (Cruz del Sur).*

Republic, Carlos Menem, entered the hall, together with Raúl F. Matera, Secretary of State for Science and Technology. After brief speeches by the Secretary of State and the IAU President, President Menem addressed the audience in his native language, of which a masterful simultaneous translation into English, the working language of Astronomy, was delivered by his interpreter. The President stressed the potential for discoveries in this very old, and yet so modern science. He emphasized the importance for the search for the deepest truths and the possibility to approach these matters from the scientific as well as from the theological point of view. He welcomed the manned exploration of space and the opening of new vistas for mankind, and he was impressed by the international character of our science. He thought that he saw 1200 "stars" in the auditorium! His speech was greeted with enthousiastic applause.

The Inauguration was accompanied by a musical interlude by the excellent Brass Quartet of the La Plata University.

First Planet Outside the Solar System?

Perhaps the most sensational scientific news presented at the General Assembly was the announcement, by a group of astronomers at the Jodrell Bank Radio Observatory near Manchester in the U.K., of the discovery of what appears to be a planet in orbit around a pulsar. A scientific account appeared on July 25 in the scientific journal *Nature* and this news generated an enormous interest among the participants as well as the media representatives, present at the GA. There were daily reports in the newspapers and TV interviews; few GA participants escaped from being asked about their personal opinions about the scientific implications of this major discovery.

Observing the pulsar PSR 1829-10, discovered with the Lowell 76-m telescope in 1985, during more than three years, A. Lyne, M. Bailes and S. Shemar found that the 330-msec period is modulated with 8 msec over a period of 184 days. Assuming a pulsar mass of 1.4 solar masses, this can be explained by the existence of a planet with 10 Earth masses in a 0.7 A.U. circular orbit around the pulsar.

Most participants agreed that the observations are correct beyond any doubt, and that the above explanation is the most straightforward one. However, it seems very difficult to understand how such a planet could have survived the blast from the supernova explosion that created the pulsar somewhat more than 1 million years ago; this age is deduced from the period derivative of the pulsar. One possibility is that the planet was captured in some way. Some astronomers would not exclude that the near coincidence between the 184-day period and one half of an Earth year may have some significance and that the observed effect might possibly be explained in some other way.

Whatever the outcome, this is a most exciting discovery and once again reminds us of the fact that while observational astronomy may be progressing at a breathtaking speed, nature may still have many more surprises in store for us.

A Missed Opportunity

In spite of often heard claims to the contrary, IAU General Assemblies do occasionally become the stage for the announcement of important new discoveries.

The most prominent case in 1991 was undoubtedly the detection of a planet around the pulsar PSR 1829-10. On July 25, it figured prominently on the first page of the *Cruz del Sur*, the very useful daily newspaper of the General Assembly. In the articles, it was said that the presentation of the data would take place in room "M", which was not in the San Martín Cultural Center but in a building one block down the street.

I arrived there in time – only to find out that Room "M" was the venue for the meeting of the Working Group on Ap Stars! In the programme Part of the "Cruz del Sur", I then found the correct place: back to San Martín! There, all elevators were busy, and when I finally arrived on the 4th floor, the discussion of the paper by F. Graham Smith had just begun.

So, I had missed a historical event and was reminded of what I knew already: big conferences require careful preparation, also and in particular on the part of the participants. *D. BAADE, ESO*

Figure 2: *The inauguration of the XXI IAU General Assembly at the San Martín Centre in Buenos Aires on July 23, 1991. At the centre the President of Argentine, Carlos Menem, flanked by the President of the IAU, Professor Y. Kozai (to the left) and the Secretary of State for Science and Technology, Raúl F. Matera.*

Cruz del Sur

Throughout the Buenos Aires General Assembly, the participants were kept very well informed about scientific news and views, changes of programme and other practical matters by means of a daily newspaper with the appropriate name *Cruz del Sur* (the Southern Cross). The editors were Patrick Moore and John Mason (U.K.), well-known popularizers of astronomy; they were supported by Argentinian photographer Osvaldo Marcarian (a rather astronomical name!).

Cruz del Sur carried reports about the observatories in Argentina, participants' opinions about a great variety of matters – from the running of the GA to controversial scientific issues – and scientific highlights, including the possible discovery of the first planet outside the solar system and the latest news from the Hubble Space Telescope. A number of ESO-related items, from Adaptive Optics to MIDAS, were also prominently featured.

To produce a four-page newspaper every day during ten days requires steely nerves and a certain ability to manage without too much sleep. In the morning of July 31, the editorial team left their office at the San Martín Centre at 2 o'clock to catch a few hours sleep at their hotel. They expected to be back at work again at 6 o'clock to continue the typesetting of the texts of IAU Resolutions which would be discussed the next day.

However, when they arrived, they found the Centre on fire (see below) and it was only after some rather agitated hours that the written material and the editorial computer finally could be rescued from the office on the second floor.

As a consequence, instead of the dry IAU Resolutions texts, the last issue of *Cruz del Sur* carried a detailed report about this dramatic event, unique in the history of IAU.

Astronomical Technology

During a meeting of Commisssion 9 (Instruments and Techniques), the current developments in the area of adaptive optics were reviewed. Since the last IAU GA in Baltimore, where the related technology as well as several prototype developments were discussed, adaptive optics has been successfully tested with the VLT prototype system COME-ON.

The scientific results include the imaging of η Carinae and the determination of the axial inclination of the largest minor planet, Ceres (see also page 13). This impressive result is based on the diffraction-limited imaging with this system and was reported by F. Rigaut at a Joint Meeting of Commissions 25 and 9, dealing with the performance of infrared arrays and the scientific results obtained with these devices.

The recent declassification of defense-related activities in the United States, including the successful tests of artificial guide stars, is likely to give adaptive optics in astronomy a major boost.

During the Commission 9 Working Group Session on Detectors, various overviews were presented on the current status of large-format CCDs used at the major observatories. 2048×2048 pixel arrays may soon become the standard. An important question raised in connection with the use of arrays of this size, or even larger ones is: how can the current read-out time of several minutes – during which the instrument as well as the telescope are idle – be efficiently used?

In a meeting of the Working Group on High Angular Resolution Interferometry, which suffered under the circumstances after the fire on Wednesday 31, only very short status reports on on-going projects and related technologies were given. However, this WG has a Newsletter which is jointly published with NOAO and which helps the members to stay up-to-date with the new developments.

F. MERKLE, ESO

Astronomical Education in Argentina

Several meetings about Education in Astronomy were held in conjunction with the XXIst General Assembly.

At the Buenos Aires Planetarium, a meeting took place on July 22 with participation of educationally oriented IAU astronomers and local teachers of natural sciences. Presentations were given about modern means and methods, by which the pupils and students can experience up-to-date astronomy and astrophysics. There was a very lively discussion and it was repeatedly stressed how important it is to stimulate enthousiasm for this extremely wide subject, by judiciously selecting and explaining those topics which are reasonably easily accessible to the students. Astronomy opens the roads to many other subjects.

The relations between professionals and amateurs were discussed during a one-day meeting on July 21, also in Buenos Aires. The services of amateurs to astronomy were highly lauded and many examples of good amateur work were presented by members of "Amigos de Astronomía", a Latin-American association.

Venusian Nomenclature

Once a year, the IAU Working Group on Planetary System Nomenclature meets to decide about the naming of newly-discovered features on the major planets and their moons.

This time, the main subject was Venus. Following the lamented death last year of the Chairman of the WGPSN, Harold Masursky (U.S.A.), Kaare Aksnes (Norway) chaired the meetings, which concentrated on the naming of the many features on the surfaces of our sister planet, recently discovered by the highly successful US spacecraft *Magellan*.

The names must be given according to certain rules. For example, no duplication is allowed and the names must not have any political, military or contemporary religious meaning. No person can be honoured unless he or she has been dead for at least three years.

Venus was the goddess of beauty in ancient Rome. It is therefore a natural decision that Venusian nomenclature shall be feminine in character, although some nasty tongues have commented on the hostile conditions on the surface.

Among the names put forward by the WGPSN and later ratified by the IAU Executive Committee were *Joliot Curie, Callas, Woolf* (Virginia Woolf), *Piaf* (Edith Piaf) and *Stuart* (Mary Queen of Scots). Less widely known are perhaps *Xiao Hong, Al-Taymuriyya, Erxleben* and *Titibu*, named after a Chinese writer, an Egyptian author, a German scholar and a Japanese Haiku poetess, respectively.

A Newcomer's View

Buenos Aires was my first opportunity to participate in an IAU General Assembly. The atmosphere of such a meeting, with huge numbers of astronomers working in different fields present, is very special since the discussed topics cover almost everything in contemporary astronomy.

Besides the delightful Invited Discourses, my own interests were focussed on extragalactic astronomy and the bordering fields. There were very informative presentations about results of space missions like ROSAT, COBE and the Hubble Space Telescope. I especially enjoyed Prof. Trümper's review of the ROSAT survey and Dr. Bohronger's talk on X-ray observations of galaxy clusters, from which it was possible to learn that the gas in these objects is often very clumpy, indicating that these galaxy clusters have not yet relaxed.

Dr. Bergeron talked about the huge gaseous disks whose existence may be inferred from the absorption lines that are seen in the spectra of some quasars. They pose a puzzle to galaxy "builders", since the observed element abundances indicate a substantial enrichment when compared to the primordial abundances. Prof. Pagel told about the chemical composition of HII regions, and I found that the talks by Drs. Maeder, Fairall, Bruzual, Broufman and many others were also most inspiring.

Just one month before the General Assembly, I finished a prolonged stay at the ESO Headquarters in Garching, and it was a pleasure for me again to meet on another side of the world many of my friends from this organization and also to enjoy two well-organized ESO exhibitions open during the General Assembly period in Buenos Aires.

P. TRAAT, ESO and Tartu, Estonia

The Longest Travel

Many participants in the XXIst IAU GA had long travels behind them when they arrived in Buenos Aires. However, the longest and most difficult voyage of all did not originate on another continent, but was certainly that of three young Peruvian astronomers, Rafael Torres, Rafael Carlos and José Huisacayna of the San Marcos University in Lima.

Leaving their native city already on July 15, they first took a bus to Tacna and then continued by car to the city Arica in northern Chile. From here they travelled to Santiago de Chile by bus and on to the Argentinian border on the Santiago-Mendoza road. To their dismay, they learned that the high Andean pass was temporarily closed because of exceptionally heavy snowfall, so they went back to Santiago and then onwards by bus towards the south. They were lucky to cross over the mountains into Argentina at Bariloche and on they went by bus to Mendoza. Finally, after an odyssey of no less than 11 days, they arrived by train in Buenos Aires!

This remarkable persistence ought to set an example for other astronomers, who may have forgotten what it means to participate for the first time in a large international meeting. The Peruvian astronomers participated in the courses given by foreign lecturers at their University within the IAU Visiting Lecturers programme which was established here in 1984, thanks to the efforts of Dr. Maria Luisa Aguilar.

"The IAU General Assembly was great and it was a fantastic stimulus for us", they said on the last day, "it was definitely worth the journey!" However, they were slightly worried about the return trip to Lima ...

About β Cephei

I had the privilege of reporting to Commission 27 (Variable Stars) about the work of two young Polish students, A. Pigulski and D. Boratyn, both at the Wroclaw University.

β Cephei is the prototype of the class of β Cep variables. It has a pulsation period of 0.1905 days. It is also a member of a multiple system; there is one visual companion at magnitude 13.4 and another one with separation decreasing from 0.25 to 0.07 arcseconds in less than 20 years (as seen by speckle interferometry). The pulsation period of β Cep underwent a sudden decrease of about 0.00001 day around 1920.

Period changes are common in β Cep stars, but could never be satisfactorily explained by any mechanism. However, Pigulsky and Boratyn have now analysed all photometric and spectroscopic data which have been collected during more than 70 years. They were able to show that the period variation of β Cep can be completely explained by the light-time effect induced by the motion in the binary system. From this, they

Figure 3: *At the ESO exhibition in the Galileo Galilei Planetarium in Buenos Aires.*

also obtained a preliminary solution for the orbit of the system, which has a period of 92 years.

This work not only represents a breakthrough in this field, it also proves that it is worthwhile to observe bright stars, and that it is crucial that such observations continue during many decades. Only small telescopes are needed for this type of work.

C. STERKEN, Brussels, Belgium

White Dwarf Masses

At one of the Commission meetings, Dave Latham reported on the work of his Argentinian student Guillermo Torres who had analysed the radial velocity curves of several dozen metal-poor halo G-type dwarfs.

The purpose was to study the effect of binarity on the astrophysically very important Initial Mass Function (IMF), i.e. the distribution of masses of newborn stars. No difference was found between single field stars and the companions to the sample stars. The only disturbing feature was a narrow peak at about 0.6 solar masses for the companions! After a short confusion, however, the answer was quickly found: having originally been the more massive components, these stars had already evolved to white dwarfs which typically have a mass of 0.6 solar masses.

Several observational tests have meanwhile confirmed this hypothesis, and the IMF is therefore not in jeopardy.

D. BAADE, ESO

Strange Sounds in the Sky

The participants in a meeting of Commission 22 (Meteors and Interplanetary Dust) learned that a very elusive phenomenon, by many thought to have a non-physical origin, after all is a real physical effect.

The President of this Commission, Colin Keay (Australia), reported how he finally, after more than a decade of research, has been able to show that reported sounds, allegedly heard in connection with passing bright fireballs, are not just a psychological effect, but can be explained by the little-known "electrophonic" phenomenon.

Chinese observers described hearing such sounds already in the year 817 A.D. More recently, in 1978, a strange sound (a "swish") was heard by as many as one third of the witnesses when a fireball of magnitude –16 passed over an area of Sydney in Australia. However, the meteor moved high above the denser parts of the atmosphere through a near-vacuum, so how could sound waves be generated?

Electromagnetic radiation from large meteors had been searched for without success, but Colin Keay decided that it would be worth to investigate this possibility further. A careful examination of the radio spectrum revealed that radio emission at frequencies in the audible range was not ruled out. Indeed, tests in "quiet" (anechoic) chambers with human subjects exposed to an electric field varying at audio frequencies revealed that some had a far lower auditory threshold than others for perceiving such sounds; it was noted that floppy or frizzy heir was a great help. The explanation is that hair (and some other materials) may sometimes act as transducers, converting the radio energy directly into perceptible sound.

A definite proof that this explanation was correct was finally obtained when a Very-Low-Frequency signal was actually recorded in Japan at the exact time of a brigth Perseid fireball. It is believed that this "electrophonic" phenomenon is also responsible for reports about sounds perceived at the time of especially intense auroral displays.

The era of Audioastronomy has opened!

Molecular Hydrogen in Galaxies

During the scientific sessions of the Working Group on Dynamics and Internal Motions in Galaxies (Commission 28), R. Allen summarized the recent results from high-resolution radio observations of spiral galaxies relating to density waves.

The new radio maps of Messier 83 and 51 make it possible to compare the position of different gas components relative to the dust lanes in detail. This suggests that H I may not be the most important gas component, but is rather a product of molecular H in which star formation occurs after a shock. Furthermore, high-resolution polarization measurements indicate the direction of the magnetic field which can be used to determine the gas flow.

P. GROSBØL, ESO

Minor Planet 5000 Named for IAU

The naming of minor planets is the responsibility of Commission 20 (Positions and Motions of Minor Planets, Comets and Satellites). At the time of the General Assembly, 4877 minor planets in the solar system had been numbered and as the 5000th discovery was approaching, this Commission arranged among its members a competition to decide upon the name of this object. The ballots were opened and counted on July 24, and the name "IAU" was found to be the winner, by a small margin. Runners-up were Hipparch, Ptolemaeus and Pascal. It is expected that the number 5000 will be assigned to an object by the Minor Planet Centre next November.

Dangerous Impacts

Recent studies have shown that there may be many more minor planets in earth-crossing orbits than previously thought. Improved detection techniques have resulted in an ever increasing rate of discoveries of such objects.

This has led to an upward revision of the estimates of the rate of collisions with the Earth. It is also now a widespread belief that the catastrophic event which contributed to the extinction of the dinosaurs 65 million years ago was probably caused by the impact of a minor planet or comet with a diameter of perhaps 10 kilometres. Smaller impacts are also known, like the 10 Megaton Tunguska event in 1908. The greatest risk to the Earth's population is found to be associated with impacts of minor planets in the diameter range from 0.5 to 5 kilometres. There may be more than 10,000 such objects in orbits which from time to time bring them very near the Earth. We were reminded of this when a 10–20-metre "boulder" passed within 200,000 km of the Earth in early 1991.

In view of the mounting interest in this area, as expressed by solar-system astronomers from several countries, IAU Commissions 4, 7, 9, 15, 16, 20, 21 and 22 decided to request the creation of an IAU Working Group on Natural Near-Earth Objects (WGNEO). A corresponding resolution was formulated and was passed by the General Assembly. The WG will endeavour to stimulate cooperation among the various groups of observers and theoreticians and will act as an international focus point for the world-wide efforts to learn more about this type of celestial objects.

The Chairman of the WG is Andrea Carusi (Rome, Italy), who is also President of Commission 20 (1991–94).

The Molecular Mass in the Galaxy

Among the many interesting items discussed by Commission 34 (Interstellar Matter) were the conditions prevalent in the IS Medium that lead to star formation and, on the other side, the interactions of newly formed stars with their immediate neighbourhood.

A very central question to this field is: how large is the mass of molecular material in the Galaxy? A consensus is still lacking about the value of the conversion factor required to obtain the molecular hydrogen mass from CO observations. It may span an order of magnitude, depending on the metallicity of the material. *M. ROSA, ESO*

If Contact, then ...

During a meeting of IAU Commission 51 (Bioastronomy), a "Declaration of Principles Concerning Activities Following the Detection of Extra-Terrestrial Intelligence", accepted by the International Academy of Astronautics, was discussed.

Although this event may still seem very unlikely and extremely remote to many, it does no harm to be prepared. The text is therefore reprinted here in an abbreviated form, in particular since it cannot be excluded that one of our scientist-readers may need to consult it sometime in the future . . .

The Declaration begins with the recognition that the search for extraterrestrial intelligence (SETI) is "an integral part of space exploration and is being undertaken for peaceful purposes and for the common interest of all mankind". Since any initial detection may be incomplete or ambiguous, "it is essential to maintain the highest standards of scientific responsibility and credibility", and various principles of behaviour are laid down in what follows:

1. Any individual or institute believing that any sign of extraterrestrial intelligence has been detected, should seek verification and confirmation before taking further action.

2. Before making any such announcement, the discoverer should promptly notify all other observers or organizations which are parties to this Declaration. No public announcement should be made until the credibility of the report has been established. The discoverer should then inform his national authorities.

3. After concluding that the discovery is credible, the discoverer should inform the Central Bureau for Astronomical Telegrams of the International Astronomical Union, and also the Secretary-General of the United Nations. Other organizations to be notified should include the Institute of Space Law, the International Telecommunication Union (ITU), and Commission 51 of the International Astronomical Union.

4. A confirmed detection of extraterrestrial intelligence should be disseminated promptly, openly and widely through the mass media.

5. All data necessary for confirmation of detection should be made available for further analysis.

6. All data relating to the discovery should be recorded, and stored permanently in a form which will make them available for further analysis.

7. If the evidence of detection is in the form of electromagnetic signals, the parties to this Declaration should seek international agreement to protect the appropriate frequencies. Immediate notice should be sent to the Secretary-General of the ITU in Geneva.

8. No response to a signal or other evidence of extraterrestrial intelligence should be sent until appropriate international consultations have taken place.

9. The SETI Committee of the International Academy of Astronautics, in co-ordination with Commission 51 of the IAU, will conduct a continuing review of all procedures relating to the detection of extraterrestrial intelligence and the subsequent handling of the data.

On the Future of Existing Photometric Systems

Astronomical photometry is facing a crisis: every new detector has caused a proliferaton of new photometric systems, lacking proper standardization and calibration. From past experience one can only fear that the situation will become worse with the growing application of CCD's to astronomical photometry.

The time had therefore again come for Commission 25 (Stellar Photometry and Polarimetry) to re-examine the fundamentals of photometry. The current situation can only be cured if we:

- return to the teaching of the fundamentals of photometry;
- design and develop standardized and user-friendly reduction programmes, incorporated in large data-reduction packages (like MIDAS);
- propose a new standard system that is open and well-sampled, and which allows transformation back into well-known systems such as UBV, or Geneva;
- have many (500) filtersets manufactured and distributed;
- have small networks of automatic telescopes to set up the system;
- design a New Technology Photometer (Fourier Transform Spectrometer, Fabry-Pérot, etc.) for use at large (or very large) telescopes, and
- push for the realization of a standard photometric light source in orbit.

C. STERKEN

An International Observatory in Antarctica?

Astronomers have a tradition of placing observatories in remote places. At this General Assembly, a Joint Commission Meeting was held about the "Development of Antarctic Astronomy". Fifteen speakers from ten countries surveyed the possibilities of establishing an international astronomical observatory in one of the most hostile areas on this planet, on the high plateau in the eastern part in Antarctica, more than 4000 metres above sea level. Here the temperature may drop below −80°C, the humidity is extremely low (the yearly snowfall is less than 10 mm equivalent rain) and the mean wind speed is only about 3 m/sec.

Such a site would offer several advantages, especially for work in the infrared part of the spectrum and also at millimetre wavelengths. The continuous antarctic night would allow 24-hour access to a large part of the southern sky and the seeing may possibly be very good.

Reports were presented about astronomical research which has been carried out at the South Pole with smaller, transportable telescopes. A Center for Astrophysical Research in the Antarctic (CARA) has recently been set up in the U.S.A.

The meeting decided to submit a formal resolution to the second session of the General Assembly about the creation of an IAU Working Group to study all aspects of antarctic astronomy and to work towards the establishment of an international observatory on that continent. The resolution was duly passed by the General Assembly on August 1.

WUPPE

In a meeting on the contribution of polarimetry to astrophysics, K.H. Nordsiek, co-Principal Investigator for WUPPE, the UV polarimeter of the University of Wisconsin, gave a first report on the results obtained for early-type stars during the ASTRO-1 mission with the Space Shuttle.

Only two or three Be stars had been put on the target list, just enough to confirm what theory predicts, since this theory was in extremely good agreement with ground-based data. Basically, the polarization curve should closely match the stellar continuum flux which is partly scattered towards the observer by a flat circumstellar disk and, accordingly, is partly polarized.

Very much to the surprise of everyone, the UV polarization curve showed huge, broad depressions. This is probably due to the absorption of the scattered light by FeII ions in the disk. While FeII lines form very broad quasi-continuum complexes in the UV, they are more isolated in the optical region. In fact, the Wisconsin observers could identify all former noise spikes in their

Figure 4: *The ESO exhibition at the San Martin Centre attracted many visitors.*

ground-based data with sharp FeII lines.

This appears to be one of the most exciting results for Be stars in many years! *D. BAADE, ESO*

The ESO Exhibitions in Buenos Aires

As was the case at the XXth IAU General Assembly in Baltimore, ESO was represented in Buenos Aires with a stand in the exhibition area.

Under the title "The VLT Observatory", ESO showed the current status of the VLT project by means of photos, videos and a new model. Furthermore, recent research results as well as technological achievements at ESO were presented. Four daily MIDAS demonstrations attracted many visitors, and R. Warmels and P. Grosbøl were busy answering questions from an interested audience.

The many visitors from non-member countries bore witness to the strong interest of the worldwide scientific community in the activities at ESO, and our stand – favourably located at the entrance in the exhibition area – soon developed into an important meeting point, not only for the ESO staff present – many of whom took turns at the stand – but also for astronomers from ESO member countries and non-member countries alike.

While the exhibition at the General Assembly was open to participants only, ESO took advantage of the increased public awareness of astronomy by showing its large exhibition in the attractive surroundings of the Galileo Galilei Planetarium.

This public exhibition was opened a few days prior to the General Assembly. The speakers at the inauguration were Prof. L. Sendon de Valery of the Planetarium, Prof. J. Sahade, former President of the IAU, and ESO astronomer R. West, while Prof. A. Cornejo, Director of the Planetarium, had prepared a short but impressive planetarium show especially for this festive occasion. *C. MADSEN, ESO*

ESO-MIDAS at the General Assembly

The ESO exhibition at the General Assembly of the IAU was enhanced with a portable lap-top computer, running under the UNIX operating system and with the X11 windowing software. At regular intervals, this equipment was used to demonstrate ESO's image-processing system: ESO-MIDAS. In addition to these demonstrations some samples of the MIDAS documentation were displayed.

During the GA many people showed their interest in the MIDAS project, in particular astronomers from developing countries. Among these, roughly 25 people made requests to receive detailed documentation about MIDAS.

Also, in the GA newsletter, *Cruz del Sur*, an article was published that gave an overwiew of the functionalities at the command level; it also described the existence of MIDAS programming environment.

Given the very positive experiences obtained from the MIDAS demonstrations, plans are now being developed for a more advanced display of information about MIDAS.

For this purpose, a set of exhibition panels will be produced which will, whenever appropriate, be included together with the lap-top in the already existing ESO exhibition.

R. WARMELS, ESO

New Working Group on Wide-Field Imaging

The interest in photography among astronomers has been steadily decreasing during the past years. This is of course due to the advent of new and more sensitive detectors, like CCD's.

The IAU Working Group on Photography (under the auspices of Commission 9) has recognized this development for some time and has discussed what to do, also in view of the continued need to ensure the availability of large photographic plates for the world's big Schmidt telescopes.

At the same time, there has been a growing awareness of the usefulness of digitized, computer-readable sky surveys. While they may not retain the full information of the corresponding photographic plates, they are certainly very handy for the convenient production of finding charts, etc.

Commission 9 therefore decided to discontinue the WG on Photography, and to create a new Working Group on Wide-field Imaging with the following main areas of concern: 1. Sky Surveys and Patrols; 2. Photographic Techniques; 3. Digitization Techniques; 4. Archival and Retrieval of Wide-field Data. As can be seen, the new WG incorporates the functions of the earlier WG on Photography, but places the use of photography within a wider context. The Chairman of the IAU WG on Wide-field Imaging (1991–94) is R.M. West (ESO).

One of the most urgent tasks of the new WG will be to look into the possibility of re-activating regular patrols of the northern and southern sky; such patrols were until recently carried out at Harvard (USA) and Sonneberg (Germany) and have repeatedly shown their value for the study of the long-term behaviour of variable objects. This will include a careful consideration of the desirable characteristics of such patrols, for instance field size, angular resolution, limiting magnitude, spectral passband(s), observing strategy and, of course, the corresponding choice of detector and telescope optics.

Fire in the Martín Centre

On the next-to-last day of the General Assembly, the San Martín Centre caught fire. When the participants arrived for the morning's sessions, they were greeted by black clouds of smoke and hectic activity by the municipal fire brigade. It later became known that the cause most probably was a cigarette butt in a trashcan in the subterranean parking lot, right under the exhibition area; the floor under the ESO Exhibition got so hot that parts of it began to bulge. Fortunately, there were no casualties, although two of the brave firemen had to be treated for smoke poisoning.

It was of course excluded to hold the scheduled meetings in that building, and it looked as if the rest of the GA programme was in jeopardy. However, the local organizers, headed by Dr. Mendez, together with the IAU General Secretary and his secretarial staff, did a most wonderful piece of improvisation and were able to secure rooms in a neighbouring Plaza, so that only a handful of meetings had to be cancelled. In particular, the important Joint Discussion on the results from the Hubble Space Telescope could start with a delay of only 90 minutes and by running on a continuous schedule until 7 o'clock that evening, virtually all of the presentations were saved.

Space Astronomy

"A crisis in space astrophysics" may be too extreme a view, but accurate atomic data are lacking for many ions and transitions, now observable with high spectral resolution, particularly in the UV with the Hubble Space Telescope. A Joint Discussion on Needs and Availability of such data brought together once again the group of physicists whose forefathers founded the *Astrophysical Journal* in a similar situation.

(Almost) a whole day of mostly science presentations on "First Results from HST" was to conclude the series of Joint Discussions. Reportedly, the project with its "hot" topics was, however, not responsible for the unfortunate break-out of fire early that Wednesday morning in the Conference Centre.

M. ROSA, ESO

New Results from the HST

The last day of the IAU General Assembly was for me the most memorable, not only for the fire, but especially for the HST presentations in Joint Discussion VII.

The auditorium was better than the standard ones at the St Martín Centre; the presentations were more professional: you could easily hear and see what was being presented, people had thought about the strucutre of their talks as well as about the sequence of the several related topics.

The UV spectroscopy from the GHRS, which I saw there for the first time, was superb, a dream come true for many an astrophysicist. The few FOS results Colin Norman showed in his summary also were most promising. The FOC is clearly a well-designed instrument and, given enough telescope and computer time, moves frontiers.

Contrarily, in my view, the huge effort going into producing "beautiful images" is of questionable value. The HST PR people still use what I call the "Weight-Watchers' trick of before and after photos" which can be very deceiving, if not downright dishonest. For example, two images of the centre of the globular cluster 47 Tucanae, from the 2.2-m at La Silla (exposure time 2 sec through a B-filtre) and from the HST (39 min at 2000 Å), which were shown on the front page of issue No. 10 of the daily IAU paper *Cruz del Sur* are not at all comparable. If we had spent a few more minutes of 2.2-m time, gone to the trouble of determining the PSF (image shape) of that exposure and made, say, 20 iterations with the Lucy image-sharpening routine, our picture would have been very similar to that of the HST, at least the "contrast" between the two would have been of a different order altogether.

My thoughts that Wednesday, in addition to the pleasure of these results, were of the fantastic telescope HST would have been if its primary mirror had been up to the original specifications. COSTAR may still do it, after 1993. It is also an incentive for us at ESO to continue to perfect the NTT and, not the least, to build the VLT to specifications and according to the established schedule. We must also strive to learn how to make the best possible use of the superb seeing on La Silla and on Paranal whenever it occurs. The HST is a complement to our telescopes; it is also a challenge to the ESO team's ingenuity.

H. VAN DER LAAN, ESO

New IAU Members

The General Assembly admitted about 800 new individual members, bringing the total to about 7,500. It is predicted that the IAU may have 10,000 members by the turn of the century, causing some concern about the practicality of retaining individual membership, a most valuable IAU feature, and unique among the international scientific unions.

Resolutions

The IAU General Assembly passed 7 resolutions of which the full texts will duly appear in the IAU Bulletin. Several of these are concerned with adverse influences on observational astronomy, in particular the continuing fight to avoid the intrusion of orbital and ground-based radio transmissions into the astronomically important wavelength bands, e.g. the OH windows.

One of the resolutions is extremely complex and deals with the new Reference Systems which will now be adopted in astronomy. For the first time, they will specifically incorporate relativistic effects. In practical terms, they also define the transition to the J2000 coordinate system in astrometry.

New IAU Executive Committee

Following the formal election procedures during the second GA session on August 1, the new Executive Committee (1991–1994) now consists of: President A.A. Boyarchuk (USSR); President-elect L. Woltjer (the Netherlands); Vice-presidents D.S. Mathewson (Australia), F. Pacini (Italy), V. Radhakrishnan (India), M. Roberts (USA), Ye Shu-hua (P.R. China), J. Smak (Poland); General Secretary J. Bergeron (France); Assistant General Secretary I. Appenzeller (Germany); Advisors Y. Kozai (Japan) and D. McNally (U.K.).

Lo Woltjer is former Director General of ESO (1975–1987); Franco Pacini is currently President of the ESO Council, and also Immo Appenzeller has close connections to our organization as a member of various committees.

Format of the IAU General Assemblies

The question of the format of future IAU General Assemblies has surfaced again and again during the past years. Most IAU members would agree that there is room for improvement, but many disagree about how this can best be accomplished.

In the early days of the IAU, the General Assemblies were very central events in professional astronomy. Before the advent of cheap and fast intercontinental travel, they were the foremost occasions for meetings among astronomers from different countries. In view of the relative small number of participants, a few hundred at most (about the same size as IAU Symposia nowadays), they were perfect frames for intensive consultations about scientific progress and international collaboration.

These days are long past, and many astronomers now think that their sparse travel money is better spent on participating in specialized Symposia and Colloquia than on the IAU General Assemblies which they feel are scientifically less interesting and moreover heavily burdened with administrative procedures for which they have little sympathy. This is particularly true for some younger astronomers, and the General Assemblies are in danger of losing one of their most important earlier functions, that of introducing newcomers to their more senior colleagues from other parts of the world and tying personal bonds among the world's astronomers. Some astronomers also think that General Assemblies and the associated, immediately preceding or following specialized Symposia and Colloquia simply last too long – who can afford to be away from their home institute during four full weeks?

The result is obvious: the IAU General Assemblies are attracting relatively fewer and fewer participants. From perhaps 75% of all IAU members in the early days, no more than 15–30% of the members were present at the Assemblies after 1976.

So what to do? In view of the recognized need for certain administrative functions of the IAU, as the adoption of important resolutions on matters that concern astronomy world-wide (e.g. environmental issues), any shortening would undoubtedly mean even less time for science and therefore also less participants. However, the new IAU General Secretary, Jacqueline Bergeron (Paris, France), in her speech of accession during the second session of the General Assembly on August 1, said that she would attempt to increase the scientific content of the next General Assembly in 1994, by having several three-day Symposia on particularly relevant topics within the GA framework. If such a change would be agreed on, no other IAU meetings would be held within several months of the General Assembly, in the hope that this would ease the participation for more members. Her ideas were welcomed by many IAU members, but others expressed some reservation, fearing that some astronomers may de-

Figure 5: *On July 31, the building in which the General Assembly was held caught fire. Several persons were rescued from the roof by the ladder of the fire brigade.*

cide to participate in one of these GA Symposia only, and not in the entire GA, as is the case in some other international scientific unions.

Whatever the outcome, future IAU General Assemblies are likely to be different.

Next IAU General Assembly

The General Assembly accepted with acclamation the Dutch invitation, most eloquently presented by Prof. H. Habing, to hold the 22nd IAU General Assembly in The Hague, the Netherlands, during the month of August 1994. The exact dates and the duration will depend upon the outcome of the discussion in the IAU Executive Committee about the future format of the General Assemblies, as mentioned above.

How Hot are the Molecular Clouds at the Galactic Centre?

M. GERIN[1,2], N. BEL[1], C. TCHOBROUTSKY[1,2] and Y.-P. VIALA[1,2]

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1. Introduction

The refinement of infrared and radio technology and the new ground-based facilities have allowed to penetrate the interstellar gas which hides the Galactic Centre in the UV and optical light. These observations have revealed the complex nature of the central parts of our Galaxy and have raised some puzzling questions. In particular, the heating mecanisms of the Giant Molecular Clouds are not understood; the molecular hydrogen density is high (although not so high as in the hot cores of galactic clouds) and it seems that a pervading high temperature could be found irrespective of the galactocentric distance. Many estimates of these temperatures have been attempted; for example, Wilson et al. (1982) [1] found a rotational temperature of metastable levels of NH_3 as high as 175 K (and this is an underestimate of the kinetic temperature); Morris et al. (1983) [2] found uniformly high temperatures 30–60 K over a few hundred parsecs around the Galactic Centre. A high level of the kinetic temperature is confirmed by the detection of emission lines of SiO as seen in our previous observations (see the report by Sandqvist, 1989) [3] and Gerin et al. [4]. The molecule SiO has been searched in several galactic molecular clouds; it has been observed only toward sources with a kinetic temperature greater than ~ 30 K (Ziurys et al., 1989) [5]. Here, we report on recent observations of the 20 and 50 km/s clouds and we shall focus on the determination of the temperature through a large part of the clouds.

2. What We Observe

We used the 15-m radio telescope SEST operated conjointly by ESO and Sweden. The observations were done in March 1991 with good weather conditions. The 3-mm receiver system consists of two cooled Schottky mixers covering the frequency band 80–115 GHz with an SSB receiver temperature of about 300 K; the image band is attenuated by more than 10 dB. The 1-mm receiver is built in the same way with a receiver temperature of about 700 K. The observer tunes the receiver from the control room with a friendly tuning programme in less than ten minutes in most cases. The spectra are analysed simultaneously by two acousto-optic spectrometers of high (0.04 MHz) and low (0.7 MHz) spectral resolution. The first one is of limited spectral range (80 MHz) and is useful to study the line profiles while the second one has a larger bandwidth (500 MHz). All results are reported in T^*_A, the antenna temperature outside the atmosphere.

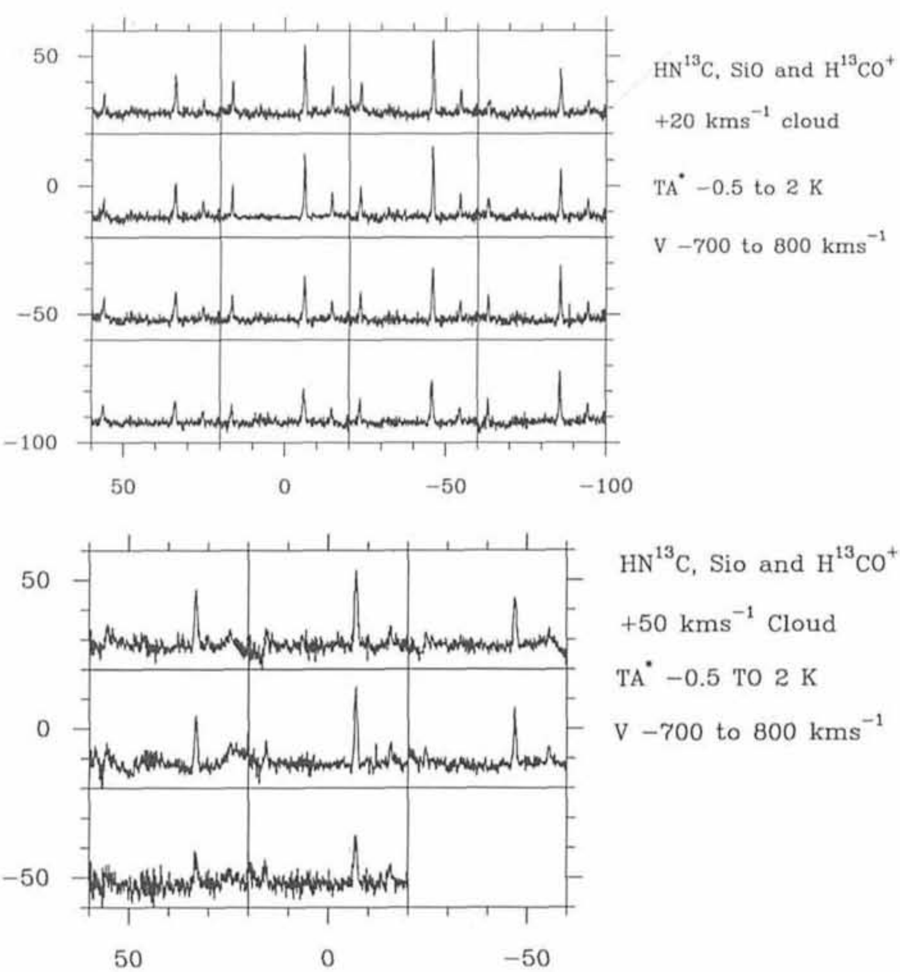

Figure 1 *(a): Spectra obtained for the 20 km/s cloud toward the direction α (1950) = 17h 42m 29.4s, δ (1950) −29°03′31″. (b): Spectra obtained for the 50 km/s cloud toward the direction α (1950) = 17h 42m 40s, δ (1950) = −28°58′20″. All the offsets are labelled in arcseconds. The rest frequency ranges from 87.1 to 86.6 GHz; we see in particular the intense J = 2–1 transition of SiO.*

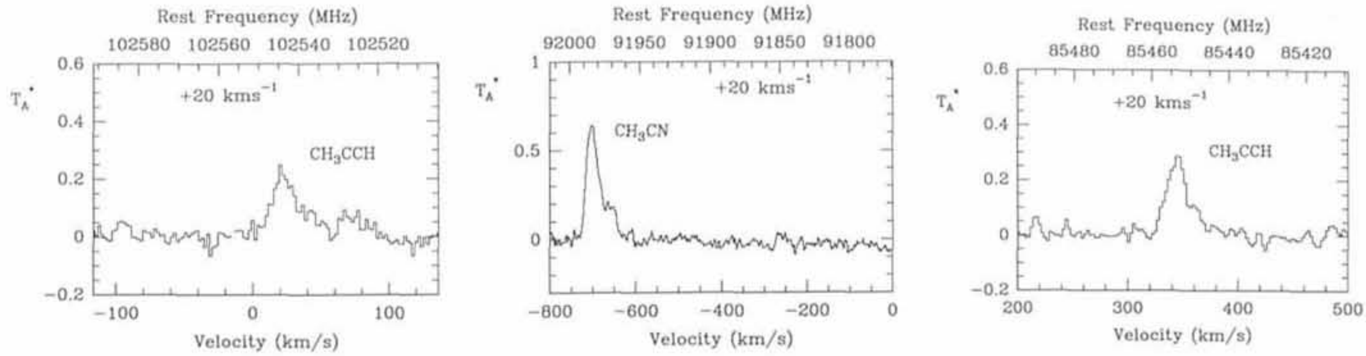

Figure 2: *Some parts of the spectrum obtained for a particular offset (0, +40″) toward the 20 km/s cloud. We can see the $J_K=6_K-5_K$ and $J_K=5_K-4_K$ transitions of CH_3CCH and $J_K=5_K-4_K$ transitions of CH_3CN.*

The system temperature varied between 350 and 700 K at 3 mm, with a corresponding noise level of 50 mK in 4 minutes of integration. The sky subtraction was done by switching the telescope between the source and an adjacent position in the sky. First, we moved the telescope to a position known to be free of emission; since this procedure gave bad baselines and a high noise level in some spectra, we preferred to use a rotating mirror to switch the beam to a position 12′ away at a rate of 6 Hz. This procedure gives good baselines but may alter the strong lines if there is some emission in the reference beam. We observed some lines both in the SgrA and SgrB2 clouds to compare with existing line surveys of the SgrB2 cloud and to check the temperature scale. We found general good agreement, except between the line intensities towards our extended sources measured with the SEST and with the IRAM 30-m telescope.

The half-power beam size of the SEST varies from 44″ (115 GHz) to 65″ (80 GHz), so we chose a map spacing of 40″. The observations were centred on the direction α, δ (1950) = 17h 42m 29.4s, −29°03′31″ for the 20 km/s cloud and α, δ (1950) = 17h 42m 40s, −28°58′20″ for the 50 km/s cloud. The total areas covered in the SiO map are respectively 160″×160″ and 120″×120″; assuming a galactic centre distance of 8.5 kpc, these areas are roughly speaking 7×7 pc for the 20 km/s and 5×5 pc for the 50 km/s.

In Figure 1, we present the spectra obtained toward each offset for the two clouds. The spectral range (87.1 to 86.7 GHz for the rest frequency) is such that the J=1−0 transition of $HN^{13}C$ (87.091 GHz), the J=2−1 transition of SiO (86.743 GHz) and the J=1−0 transition of $H^{13}CO^+$ (86.754 GHz) are selected. On both maps, we can see that SiO is present everywhere and is fairly intense (except in the last offset of Sag A 50 km/s which was not observed); these galactic centre molecular clouds are the unique sources of widespread SiO in our Galaxy. We selected 3 positions in each cloud to observe more molecular lines. As we are interested in the temperature, some examples of the spectra we use for our purpose are presented. Figure 2 gives the $J_K=6_K-5_K$ (K=0−3) and the $J_K=5_K-4_K$ (K=0−3) transitions of CH_3CCH and the $J_K=5_K-4_K$ (K=0−4) of CH_3CN for the 20 km/s; these symmetrical top molecules were chosen because they are supposed to be good thermometers for the interstellar clouds. In each case, only the lines for K=0, 1 and 2 are clearly identified; for K ≥ 3, the signal-to-noise ratio is bad and we have to take the numerical values that we derive with a pinch of salt. Figure 3 gives the same transitions (with same remarks) for the 50 km/s.

3. What We Deduce

Figure 4 gives the rotational diagrams obtained with the transitions $J_K=6_K-5_K$ (full symbol) and $J_K=5_K-4_K$ (open symbol) for increasing values of K, and respectively for the methyl acetylene and the methyl cyanide; these diagrams are given for one particular offset in each cloud. The column density of a level has been obtained with usual hypotheses such as optically thin transition. On Figure 4, it is clearly seen that the dispersion of the points for CH_3CCH is low and is within the uncertainties: the full and open symbols for each K can be considered to be on the same line. The straight lines which are the best fits between the open and the full symbols are almost superimposed and give a unique temperature (the slope of the line is 1/T) which can be considered as a kinetic temperature; we find $T_{kin} \approx 50$ K for the 20 km/s cloud and $T_{kin} \approx 70$ K for the 50 km/s cloud. For CH_3CN, it appears that the representative points of each K-ladder are aligned on nearly parallel lines which lead to a unique rotational temperature, $T_{rot} \approx 10$ K for both clouds. The slopes of the lines which fit the points J=constant are nearly parallel

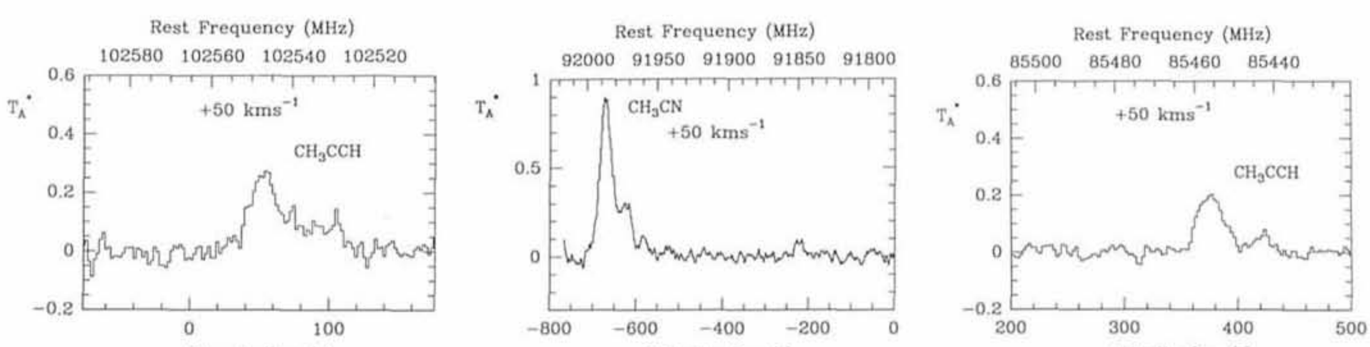

Figure 3: *Some parts of the spectrum obtained for a particular offset (0, +40″) toward the 50 km/s cloud which exhibit the same transitions as in Figure 2.*

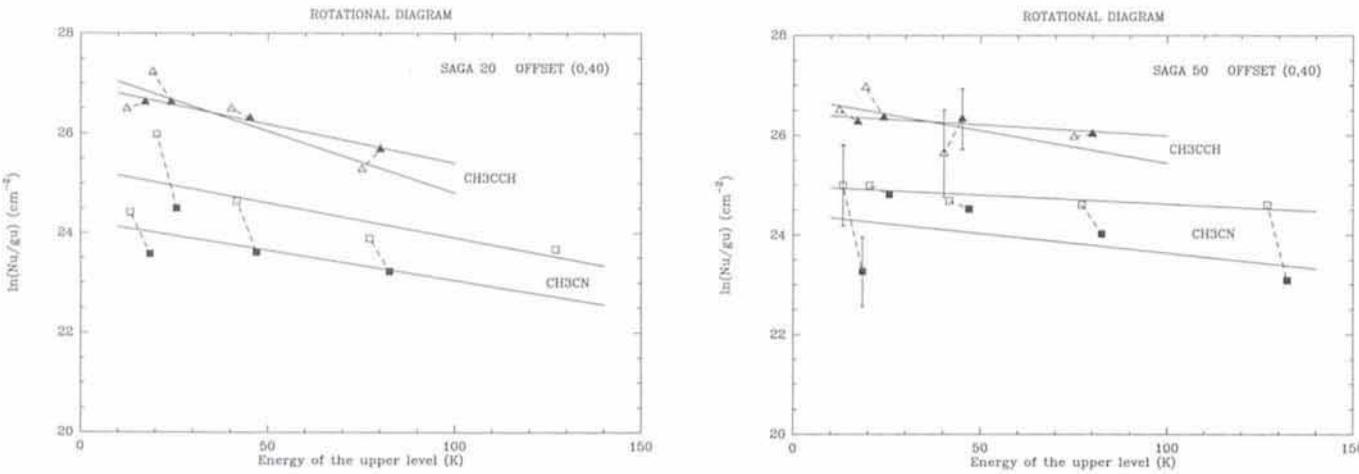

Figure 4: *Rotational diagrams which show the population of the upper level of a transition divided by the statistical weight as a function of the energy level. The full symbols are representative of the transition $J_K = 6_K - 5_K$ while the open symbols are for the transition $J_K = 5_K - 4_K$. K increases from the left to the right from 0 and is the same for each pair of symbols. Some error bars give an estimate of the errors due to the fitting of the line profiles by gaussians.*

and could give an estimate of the kinetic temperature (see for example Turner, 1991 [7]; Churchwell and Hollis, 1983 [6]). Table 1 and Table 2 summarize the results for the 3 offsets in each cloud and also give the average value. One can also find the total column density of each molecule; it has been obtained by using our observations and the partition function computed for the temperature we determined. The magnitude of the CH_3CN column densities of the 20 km/s cloud are of the same order as those obtained by Turner (1991) [7] for Sag B2; for the 50 km/s cloud, the column densities are somewhat higher. In both clouds, the methyl acetylene column densities are of the same order as those found by Churchwell and Hollis (1983) [6] in Sag B2.

Some remarks must be made. CH_3CCH seems more thermalized than CH_3CN, which can be understood if we recall that the electric dipole moment (and as a consequence the probabilities of radiative transitions) of CH_3CN is larger (3.9 D) than that of CH_3CCH (0.78 D): in this last molecule, the level populations are mainly governed by collisions. This is compatible with a numerical molecular hydrogen density $\approx 10^4$ cm^{-3}. Concerning the galactic clouds themselves, the Tables 1 and 2 show that the kinetic temperature must definitely be high in these clouds, $\approx$25–70 K in the 20 km/s, if we take the average value, $\approx$80–90 K in the 50 km/s cloud. On the other hand, this "high" temperature is pervading in a fairly extended part of the clouds (at least 5 pc), which put some constraints on the heating processes.

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SAGA 20

	CH_3CN			CH_3CCH	
Offset	T_{kin}(K)	T_{rot}(K)	$N_{tot}(10^{14})$	T_{kin}(K)	$N_{tot}(10^{14})$
(–80,–80)	66 J=5 99 J=6	11	1,3	82 J=5	9,6
(0,0)	82 J=5 37 J=6	7	0,99	22 J=5 80 J=6	7,7
(0,40)	71 J=5 83 J=6	5	1,5	40 J=5 64 J=6	9,4
Average				25 J=5 77 J=6	8,4

Table 1 *gives for the 20 km/s cloud the rotational and the kinetic temperatures we derived at three offsets and also gives the average value for these three offsets.*

SAGA 50

	CH_3CN			CH_3CCH	
Offset	T_{kin}(K)	T_{rot}(K)	$N_{tot}(10^{14})$	T_{kin}(K)	$N_{tot}(10^{14})$
(0,–40)	196 J=5 502 J=6	11	11	53 J=5 92 J=6	11
(0,0)	163 J=5		6,4	133 J=5 74 J=6	18
(0,40)	278 J=5 126 J=6	6	6,0	76 J=5 64 J=6	11
Average				81 J=5 94 J=6	13

Table 2 gives the values derived for the 50 km/s cloud.

The Absolute Magnitude of RR Lyrae Stars

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Introduction

RR Lyrae stars are one of the standard indicators in the distance scale. Knowing their absolute magnitude, we may determine such basic astronomical parameters as the distance to the Galactic Centre and the distances and ages of the Globular Clusters, which have a cosmological connection with the Hubble constant. They have also been observed in other galaxies of the Local Group where they serve as an important check on other distance indicators, notably Cepheids.

Despite intensive observational efforts over many years, there is still uncertainty in the absolute magnitudes of these stars, and in particular over the variation of the absolute magnitude with chemical composition. RR Lyraes have [Fe/H] in the range from solar to several hundred times deficient, and some work suggests there is no variation of absolute magnitude with [Fe/H] (e.g. the statistical parallax method, Barnes and Hawley, 1986), whilst other work suggests the variation may be as much as one magnitude (Sandage, 1989).

Among the methods used to determine the distance and the absolute magnitude of RR Lyrae stars, the Baade-Wesselink (B-W) method is particularly powerful since it is the only one that uses the intrinsic properties of the star, i.e. luminosity, colour, and radial velocity variations over the pulsation cycle. In its original formulation (Baade, 1926; Wesselink, 1946, 1969) the B-W method uses the light and colour curves of the variable to derive the variation of the angular diameter θ over the pulsation cycle ($\theta \rightarrow \varphi$). The radial velocity curve is used to derive the variation of the linear radius $R \rightarrow \varphi$. From the comparison of the $\theta \rightarrow \varphi$ and $R \rightarrow \varphi$ variations the distance and the absolute magnitude of the star are then derived.

In 1986 two of us (C.C. and G.C.) started at ESO an observing programme aimed at the collection of visual photoelectric photometry and radial velocity data to apply the Baade-Wesselink method to a number of field RR Lyrae stars. In collaboration with Dr. Prévot of the Observatoire de Marseille and Dr. H. Lindgren of ESO, 7 field RR Lyraes have been observed with the 1-m ESO telescope and the 1.5-m Danish telescope equipped with CORAVEL. The data for these stars and the B-W analysis of some of them have been published by Cacciari et al. (1987, 1989a, b) and Clementini et al. (1990).

Recently it has become evident that the use of infrared JHK photometry allows a more accurate application of the B-W method. As shown by Jones et al. (1987), Liu and Janes (1990) and Fernley et al. (1990), the use of the infrared magnitudes and colours (in particular K and V-K) minimizes the discrepancy between photometric and spectroscopic radius determinations on the descending branch of the light curve, which is presumably due to the presence of non-LTE conditions in the pulsating atmosphere. This effect inhibits the application of the B-W method in the visual region over that phase range, but does not significantly affect the infrared region which falls in the Rayleigh-Jeans tail of the energy distribution and is therefore less sensitive to the temperature and its "anomalies".

We have therefore taken JHK observations for three of the previous objects, namely RV Phe, W Tuc and UU Cet, and their absolute magnitudes have been determined using two slightly different formulations of the B-W method, i.e. (a) the Surface-Brightness (SB) method, as described in Cacciari et al. (1989a), and (b) the Infrared Flux (IF) method, as described in Fernley et al. (1990). These are at present the two most accurate and widely used techniques to derive $M_V(RR)$, and both are capable of determining the absolute magnitude with an error of $\pm$ 0.15–0.20 mag. Although this degree of accuracy is not sufficient to resolve some of the important questions related to the variation in absolute mag-

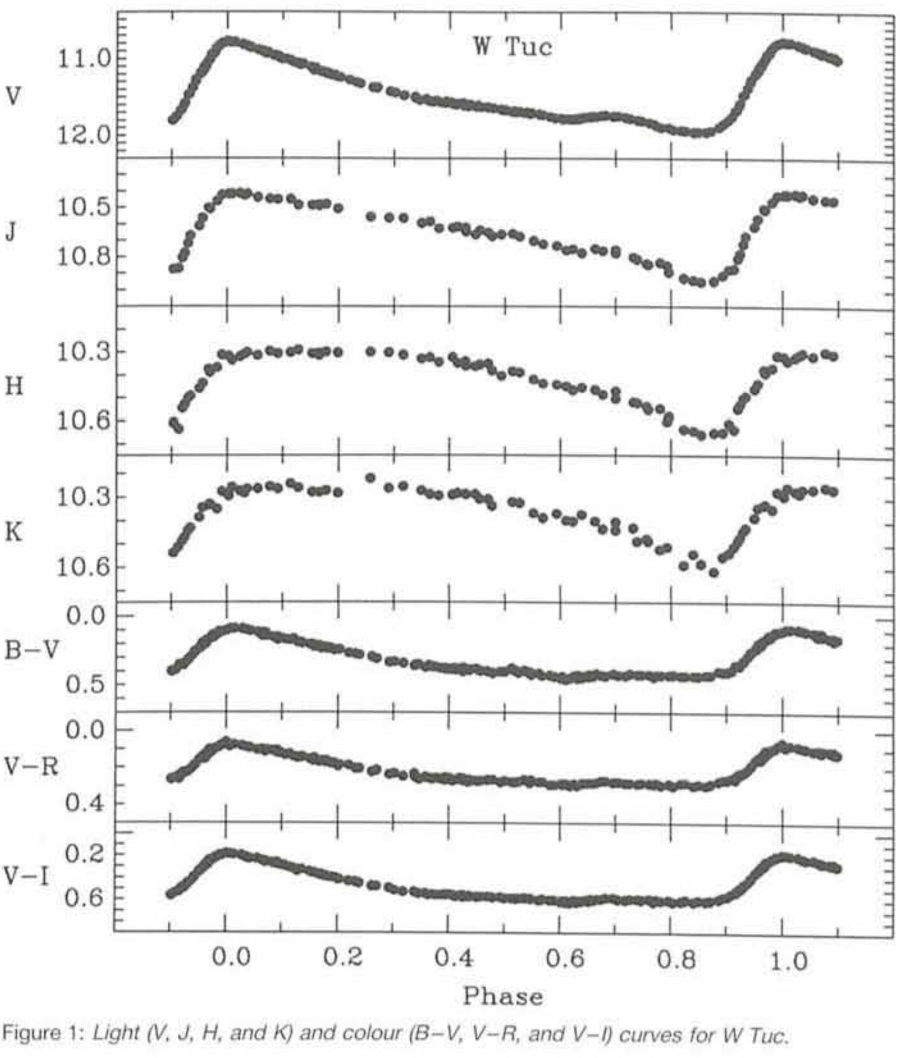

Figure 1: *Light (V, J, H, and K) and colour (B−V, V−R, and V−I) curves for W Tuc.*

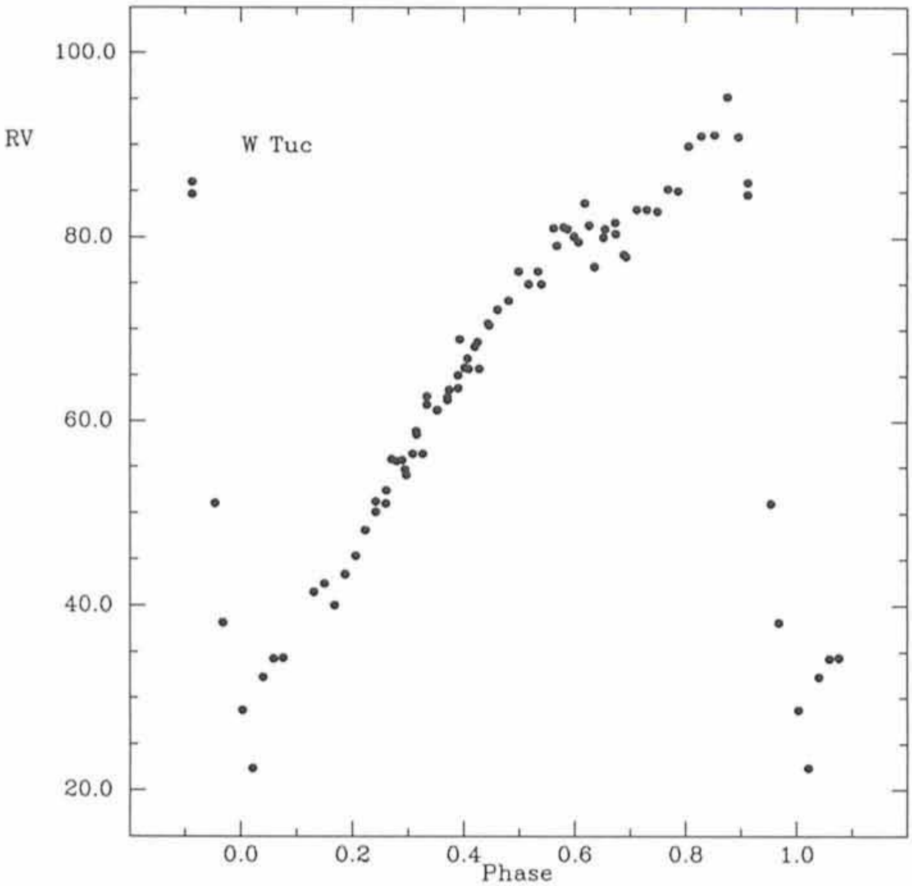

Figure 2: *Radial velocity curve for W Tuc.*

nitude of RR Lyrae stars with period and metallicity (such as the age of globular clusters with a smaller uncertainty than the current 2–3 Gyrs), it can be substantially improved by enlarging the statistics, i.e. applying the methods to as many stars as possible (see Sandage, 1989, 1990 and Sandage and Cacciari, 1990, for a review and detailed discussion of this and related problems).

The Observations

Both SB and IF methods require very accurate photometric (BVRIJHK) and radial velocity data as input parameters, the knowledge of reddening and metallicity of the star, and a model atmosphere for the proper metallicity and gravity. The infrared light curves for the three stars were collected between October 19 and 28, 1990 using the 1.0-m telescope at the European Southern Observatory, La Silla, Chile (Cacciari et al., 1991). The BVRI photoelectric photometry and the radial velocities of the three stars had been obtained in previous observing runs at La Silla (Cacciari et al., 1987, 1989b, and Clementini et al., 1990). The visual photometry is on the Johnson-Cousins photometric system. The Walraven photometry used in the IF method is by Lub (1977). The radial velocities were obtained with the CORAVEL photoelectric scanner (Baranne et al. 1977, 1979; Mayor, 1985). The accuracy of the CORAVEL radial velocities of an RR Lyrae star depends on the metallicity, the average colour of the star, and the phase at which v_r is measured, the correlation dip being shallower and less well defined when the star has earlier spectral type. Typical accuracies for individual data points are ±1–2 km/sec for the radial velocity data, and ±0.01–0.02 mag for magnitudes and colours. The photometric and radial velocity data for one of the stars, namely W Tuc, are shown in Figures 1 and 2 as an example.

Analysis and Results

For the three programme stars, RV Phe, W Tuc and UU Cet, we have adopted respectively [Fe/H] = −1.5, −1.35, and −0.90, and E(B−V)=0.015, 0.005 and 0.025. We have then applied the IF and SB methods as described in detail in Fernley et al. (1990) and Cacciari et al. (1989a) respectively, avoiding the phase interval around maximum light since the stellar atmospheres are presumably in non-LTE and static model atmospheres are therefore not adequate to describe their characteristics in that interval of phase. During the ascending branch of the light curve there is considerable evidence for a shock wave in the upper atmosphere of RR Lyrae stars, as indicated by emission in the Balmer lines and an ultraviolet (U-B) excess (Preston and Paczynski, 1964). This is clearly shown in Figure 3 where we report three orders from the CASPEC echelle spectrum of an RR Lyrae star in the globular cluster M4 that one of us (G.C.) had obtained in a previous observing run at La Silla. The spectrum corresponds to φ=0.96, i.e just before the star reaches the maximum light. The presence of these emissions is generally interpreted as due to shock waves caused by the pulsation being "out of phase" in the higher layers of the atmosphere. As material from the new pulsation cycle drives outwards it collides with material falling in from the old pul-

Table 1: *Summary of results. The two values in the SB method are from optical colours (left) and (V−K) colours (right).*

	IF			SB		
	UUCet	RVPhe	WTuc	UUCet	RVPhe	WTuc
$<R/R_\odot>$	5.55	4.92	5.78	5.20 – 5.54	5.32 – 4.60	5.68 – 5.55
$<T_e>$	6308	6293	6395	6363 – 6293	6370 – 6292	6517 – 6441
d(pcs)	1826	1525	1529	1782 – 1821	1650 – 1386	1529 – 1452
$<M_v>$	0.697	0.954	0.521	0.75 – 0.70	0.77 – 1.16	0.52 – 0.63
$<M_k>$	– 0.466	– 0.200	– 0.570	–	–	–
$<logL/L_\odot>$	1.639	1.530	1.698	1.598 – 1.633	1.619 – 1.472	1.716 – 1.675
$<M/M_\odot>$	0.64	0.49	0.65	0.54 – 0.64	0.60 – 0.41	0.62 – 0.58

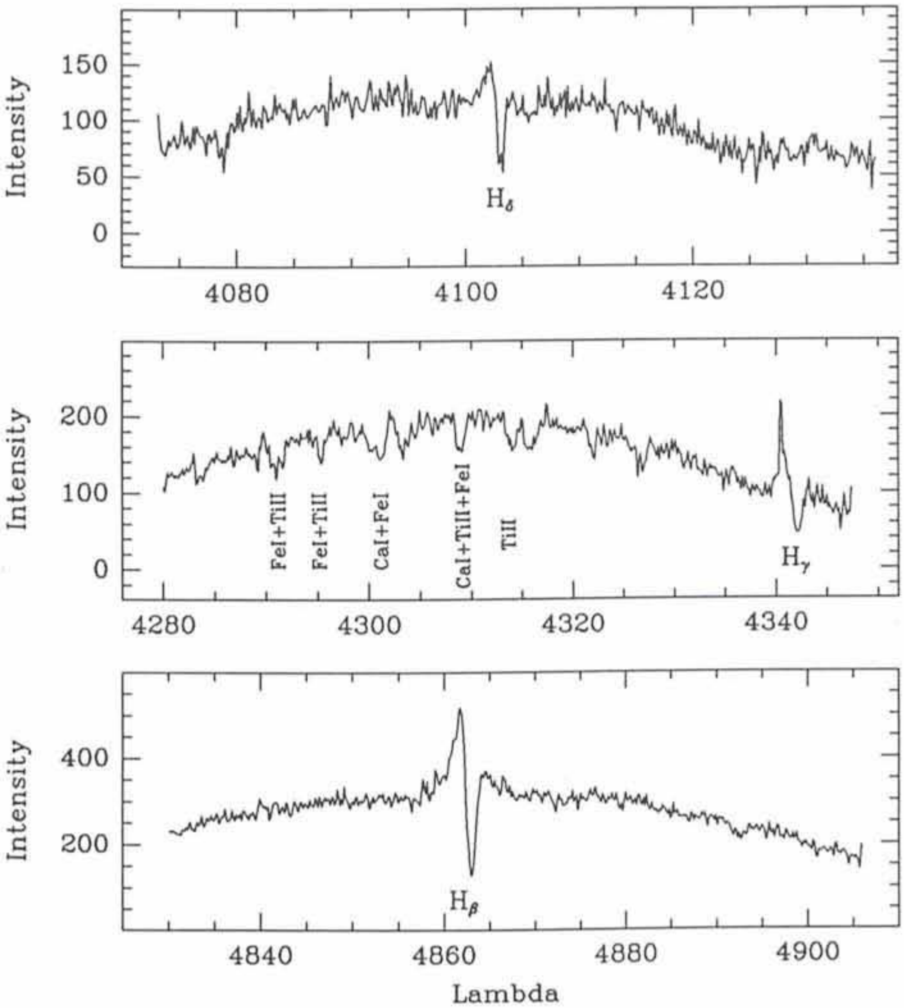

Figure 3: *Three orders from a CASPEC spectrum of variable V29 in the globular cluster M4. The spectrum corresponds to $\varphi \sim 0.96$ of the pulsation cycle of the star.*

sation cycle. The resulting collisions produce both the Balmer line emission and the (U-B) excess. Figure 3 shows that some emission occurs in weak metal lines as well.

To avoid these problems, the IF method has been applied over the phase interval $\Delta\varphi$=0.05–0.85, the SB method plus V–K colours has been applied over the phase interval $\Delta\varphi \sim$0.10–0.80, and the SB method plus visual colours (i.e. V–R and V–I) has been applied on an even more restricted phase range (varying from star to star) to avoid additional distortions in the flux distribution that do not normally occur in the infrared range. The $\theta \rightarrow \varphi$ and $R \rightarrow \varphi$ fits for W Tuc are shown in Figure 4 as an example. The angular diameters θ have been derived using as temperature indicators the V–R, V–I and V–K colours respectively in the SB analysis, while the entire spectral range from ultraviolet to infrared has been used in the IF analysis. The results obtained for the three stars are summarized in Table 1, where the output parameters from visual and V–K colours in the SB method are shown separately, and one can see that the two methods are rather consistent, in particular when the (V–K) colour is used in the SB method.

The present types of analysis have been previously applied to a number of field RR Lyrae stars by many authors. The most recent compilations are given by Cacciari et al. (1991) and Jones et al. (1991), and include 24 stars that have been analysed using infrared data. We refer to these papers for more details and references. From these data one derives a relation between the absolute magnitude of the RR Lyrae stars M_V(RR) and the metallicity (see Fig. 5):

$$M_V(RR)=0.19[Fe/H]+1.01$$

(Cacciari et al., 1991). The slope of this relation is however still somewhat controversial, as Jones et al. (1991) found

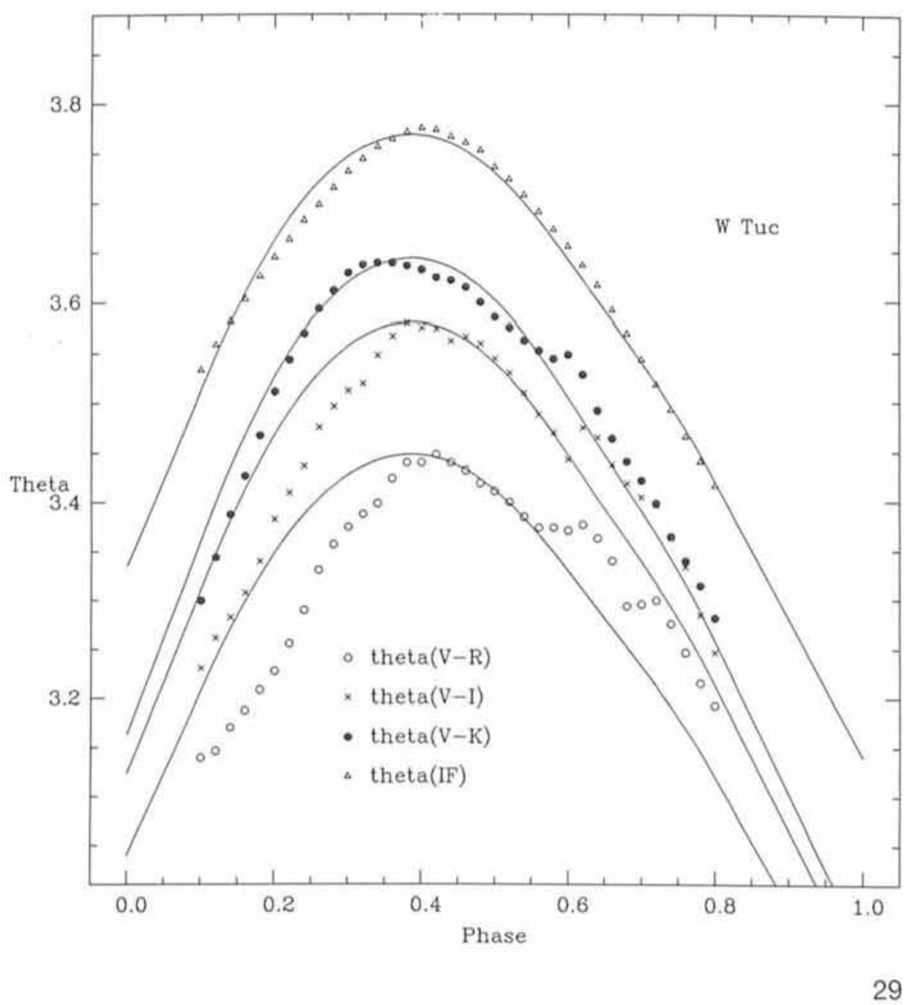

Figure 4: *Angular diameters θ vs. phase for W Tuc as derived from V magnitudes and (V–R) (○), (V–I) (×) and (V–K) (●) colours with the SB method, and from the IF method (Δ). The solid lines represent the radial displacements ΔR derived from spectroscopy, corresponding to M_V=0.28, 0.52, 0.63 and 0.52 respectively.*

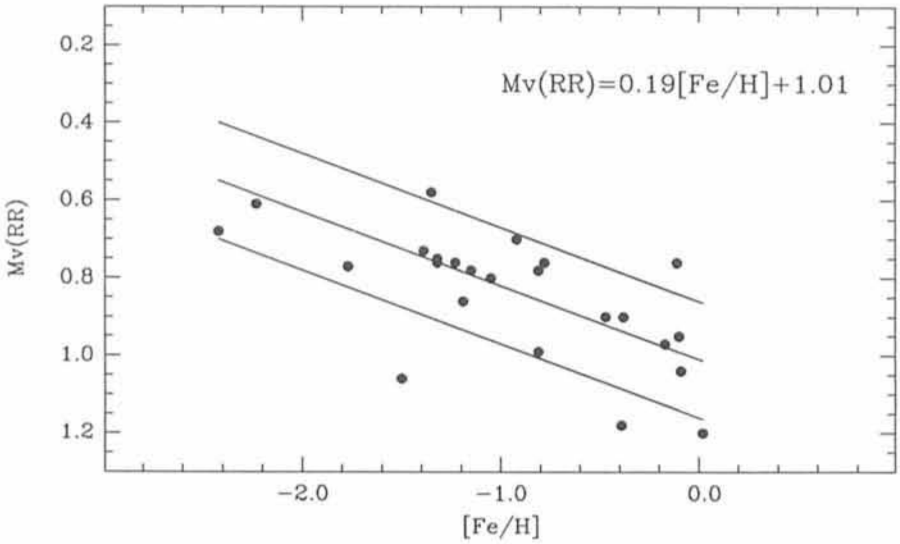

Figure 5: *Summary of the RR Lyrae absolute magnitude determinations obtained from infrared data (IF method, or SB plus V−K colours). The solid lines define the range $\Delta M_V = \pm 0.15$ mag around the ridge line defined in the text.*

~0.16 using slightly different values of $M_V(RR)$ for a few very metal-poor and very metal-rich stars, and values ranging from 0.20 to 0.38 have been found with a number of methods and assumptions, as reviewed and discussed by Buonanno et al. (1990).

The use of the above relationship to estimate globular cluster ages leads to 16 and 19 Gyrs for metal-rich and metal-poor clusters respectively on the assumption that [CNO/Fe]=solar, and to slightly lower values depending on the amount and degree of metallicity dependence of O enhancement, if any.

The obvious further step with respect to the work done so far on field stars is to extend this type of analysis to globular cluster RR Lyraes. Since in a given cluster RR Lyraes are all at the same distance and have the same metal abundance (with the exception of ω Cen), the study of a sufficiently large number of them can provide a more accurate determination of the average absolute magnitude in each cluster and of its dependence on metallicity. Globular cluster variables are however much fainter than their field counterparts, and the observations are correspondingly more difficult and time-consuming. In particular CORAVEL, in its present configuration, cannot be used for RR Lyraes fainter than V=12.5–13 mag, while the brightest RR Lyraes in globular clusters at minimum light are V≥13.5. For this reason very few results have appeared on this topic (Cohen and Gordon, 1987, Liu and Janes, 1990), although considerable effort is being devoted to it. We have started a programme on the RR Lyrae variables in M4, and have collected BVRIJHK photometry and CASPEC high-resolution spectra for 4 variables, covering the entire pulsation cycles. The data are presently being analysed and will be the subject of a forthcoming paper.

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Galaxy Photometry with SEST: How Big Are Galaxies at Millimetric Wavelengths?

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Introduction

The information currently available on the electromagnetic emission of normal galaxies at long wavelengths (λ = 100 ÷ 3000 μm) is still quite sparse and serious discrepancies are found among different observations. Only very recently the improvement in instrument sensitivity has allowed exploration of the galaxy submm-mm continuum. Data on millimetre continuum emission of galaxies are mainly confined to active galaxies (both AGNs and starburst galaxies), because of their enhanced nuclear emission, while only a handful of normal spirals have been observed so far at these wavelengths (Chini et al., 1986, Stark et al., 1988; Eales et al., 1989).

The IRAS surveys have shown that the far-IR spectra of late-type galaxies are mainly of thermal origin, due to dust grains present in their interstellar medium. However, far-IR measurements are not enough by themselves to estimate the overall dust content, since an important fraction (often more than ~ 50 %) of dust is expected to be colder than 20 K and therefore its emission lies at $\lambda > 100$ μm. Therefore, in order to study the characteristics of cold dust, which are important to understand both galactic evolution and star-formation processes, submm-mm photometry is needed. The continuum flux in this spectral range is linearly related to the temperature, mass and opacities of dust grains, and its measurement provides an alternative way to estimate these parameters.

The exploitation of the high sensitivity achievable by bolometer detectors (Kreysa, 1990), together with the high spatial resolution of large antennas such as SEST (with a FWHM of 24"), is expected to strongly improve our knowledge of the galaxy spectra and of the total amount of dust present in the interstellar medium, its spatial distribution within the galaxies and its relationship with other basic components, such as the atomic and molecular gas, the stars, etc.

We have started an observational programme whose aim is the investigation of the 1.2-mm continuum emission of a complete sample of galaxies selected from the IRAS Point Source Catalogue, for which optical photometry and spectroscopy are partially available. The sample comprises 61 galaxies with a 60-μm flux above 2 Jy in the sky region delimited by the equatorial coordinates 21h < R.A. < 5h and $-22.5° < \delta < -32°$. The completeness of the sample ensures that unbiased estimates of the crucial parameters (such as the average mm to far-IR wavelength flux ratio and the bivariate luminosity distributions) could be obtained. This will eventually allow the determination of the local luminosity functions of galaxies at $\lambda = 1$ mm. Several important applications of this analysis can be envisaged. Let us mention two among others.

(1) A reliable determination of the galaxy local luminosity at $\lambda = 1$ mm, added to observations of the extragalactic background being currently performed by the COBE satellite, and to ground-based millimetric surveys, planned in the near future with the use of bolometer arrays, may tell us something new and fundamental about the cosmic evolution of galaxies and of their dust content (Franceschini et al., 1990).

(2) A better knowledge of galaxy continuous spectra in this energy domain will allow to refine the estimate of the contribution of known discrete sources to the cell-to-cell fluctuations of the Cosmic Microwave Background (CMB) at small and intermediate angular scales. Franceschini et al. (1989), on the basis of theoretical models of dust emission spectra of galaxies, have shown that such contribution may be significant even at ~ 1 mm, that is near the peak of the CMB spectrum. Eventually, the detection of any intrinsic anisotropies of the CMB would crucially rely on a correct subtraction of the normal galaxy contribution.

A successful observational run performed last year at SEST has already provided us with some reliable detections and upper limits for half of the sample objects falling in the δ range from $-22°.5$ and $-26°.5$. We briefly report here on results of these observations and on problems raised by a comparison with previously published data.

Observations with the SEST Telescope

The observations have been performed during September 1990 using the 15-m SEST telescope at La Silla equipped with the ^{3}He bolometer of the MPIfR (Max-Planck-Institut für Radioastronomie).

The filter set coupled to the atmospheric transmission window provides an effective wavelength around 1.25 mm. The beam size is 24" (HPBW).

Source position was found by pointing a nearby radio-loud quasar with strong millimetric fluxes. Pointing accuracy was most of the time better than 2" and was checked each half an hour.

Beam-switching is achieved by a chopper wheel located in the receiver cabin, switching the beam ON-OFF the source. This, coupled to the nodding of the telescope, results in a three-beam technique which allows comparison between the source signal and that from two opposite empty regions of sky. The chop throw was set to be 70", which is larger than the optical diameter of the sample galaxies. Each source has been observed n·200 seconds with n depending on the expected 1.2 mm intensity. The latter has been approximately evaluated extrapolating the IRAS 100 μm flux using a thermal spectrum with an opacity spectral index between 1 and 2.

Atmospheric transmission has been monitored by frequent skydips. Uranus has been used as primary calibrator by assuming a weighted effective temperature at this wavelength of 93±1 K. Several quasars have been used as secondary calibrators mainly to detect sky variations during the observations. The overall accuracy on the detected fluxes was good (~ 10 %) because of the optimum atmospheric conditions.

Twenty-eight objects have been observed, for 12 of which reliable fluxes (better than 3 sigma values) have been obtained. The observed values of the millimetre flux have been corrected for the overall system response and K-correction.

For each source the ratio $\frac{f_{1.25mm}}{f_{100\mu m}}$ has been computed. The IRAS fluxes have been taken from the IRAS Point Source Catalogue, slightly modified to account for colour and K-corrections.

The Average mm to Far-IR Flux Ratio

Histograms of the ratio $\frac{f_{1.25mm}}{f_{100\mu m}}$ are reported in Figure 1. Panel (a) refers to those data without any aperture corrections. A technique of *survival analysis* has been used to make full use of the information content in the upper limits to the 1.25 mm fluxes. In this way we have estimated an average flux ratio $\frac{f_{1.25mm}}{f_{100\mu m}} = (2.02 \pm 0.36)\ 10^{-3}$.

Right-hand side panels of Figure 1 also report flux ratios derived from data collected with the IRAM 30-m antenna, whose results have already been reported in this Journal (see No. 61 – September 1990, p. 44). We find in this case $\frac{f_{1.25mm}}{f_{100\mu m}}$ $(1.51 \pm 0.12)\ 10^{-3}$ (panel (b)).

The same analysis has been applied to the Cini et al.'s (1986) data on 26 spiral galaxies observed with the IRTF 3-m telescope. The histogram of their mm to far-IR flux ratios is plotted in Figure 2. The survival analysis provides in this case a substantially higher value for the average ratio $\frac{f_{1.3mm}}{f_{100\mu m}} = 1.4\ 10^{-3}$.

An opposite indication comes from observations at 350, 450, 800 and 1100 μm performed by Eales et al. (1989) on a few nearby galaxies. In contrast with Chini et al.'s results, these authors claim that the energy distribution in the far-IR/submillimetric range is well fitted by a thermal emission of warm dust at 30–50 K, which implies a substantially lower value for the average mm to far-IR flux ratio. Indeed, by extrapolating their model to 1.25 mm, we find in this case a value smaller by at least a factor of 2 than that implied by our observations. The discrepancy is even larger with Chini et al.'s results (more than a factor of 10 in this case).

Some other sub-mm observations are not even commensurate with ours. Stark

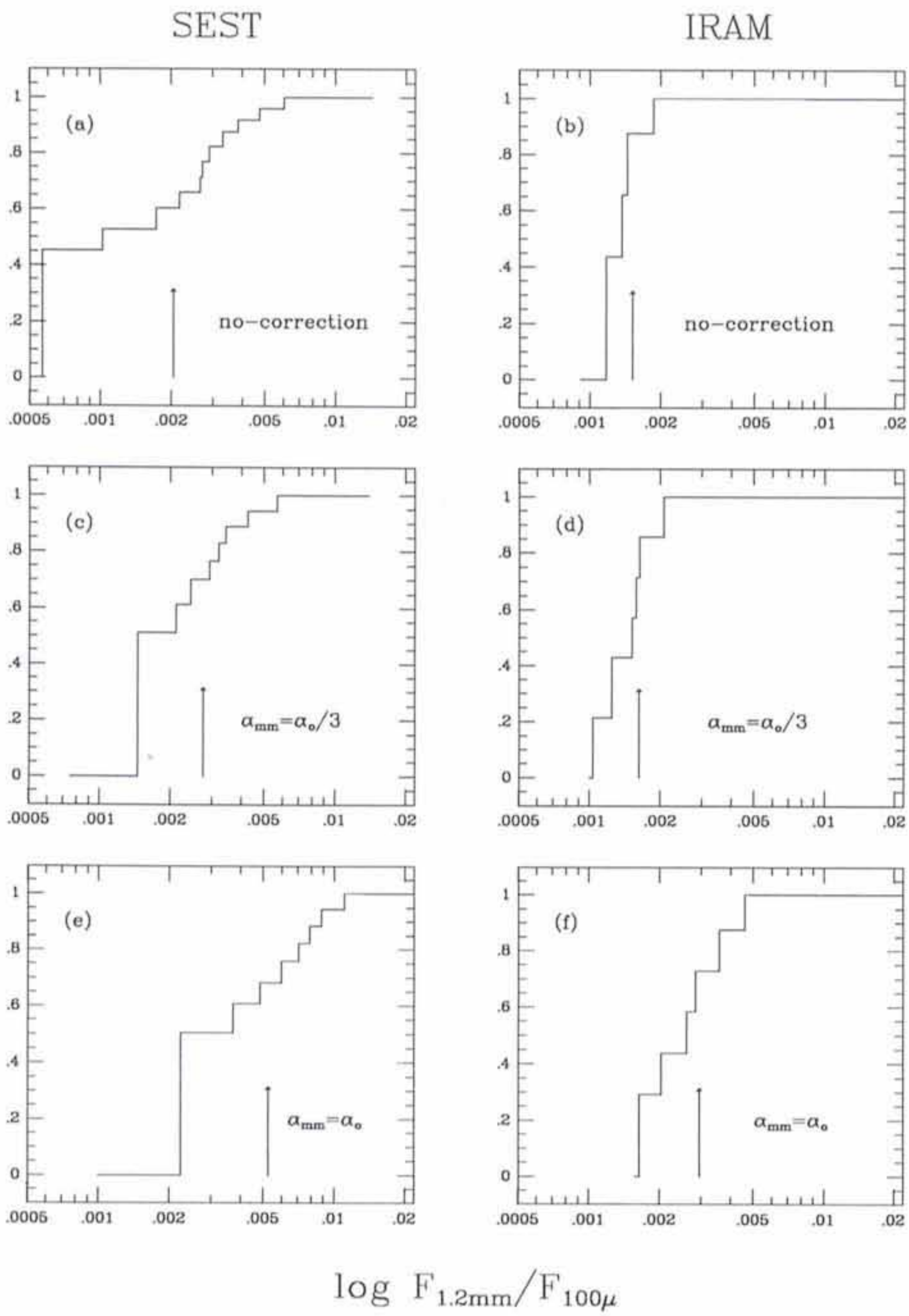

Figure 1: *(a) The cumulative probability distributions of the* $\frac{f_{1.25mm}}{f_{100\mu m}}$ *ratio for the SEST (left-hand-side panels) and IRAM samples (right-hand-side panels). The distributions have been reconstructed with detection-and-bound techniques. Panels (a) and (b) report the distributions based on fluxes without any aperture corrections; panels (c) and (d) those based on fluxes corrected under the hypothesis that the mm light profile has a scale-length* α_{mm} *equal to one third of the optical one,* α_o*; panels (e) and (f) refer to the hypothesis that mm light profiles follow those in the optical. The arrows mark the average values.*

et al. (1988) mapped four Virgo spirals at 160 and 360 μm at a spatial resolution of ~ 45", but with a poor S/N ratio at 360 μm. Thronson et al. (1987) observed only the very centre of large active galaxies at 1.3 mm, sampling a too small portion of the entire galaxy disks. Therefore, they probably lost most of the millimetric flux.

To conclude, galaxy spectra in this spectral domain, hence the total amount of dust, are uncertain by up to one order of magnitude. We will briefly discuss possible origins of this large discrepancy and suggest how further investigations might be helpful in elucidating this question. Beam-aperture corrections may contribute to explain these discrepancies. Unfortunately, the lack of knowledge of the spatial extension of galaxies at long wavelengths hampers a precise estimate of this effect. Moreover, in some ON-OFF observations, the beam separation was too small in comparison with the larger optical dimensions of the objects, and only a gradient in the emission has probably been measured.

Aperture Corrections to mm Fluxes

In order to consider the whole effect of a gaussian beam on the detected fluxes, a convolution of the beam-shape with the light profile of the galaxy millimetric emission must be done. We suppose that the millimetric light profile is exponential with scale-length α_{mm}. We have considered the following two hypotheses:

(1) The radial distribution of cold dust closely follows that of the blue light. In this case the millimetric scale-length α_{mm} is equal to that in blue light, α_o. The corresponding average flux ratios after correction for aperture are $\frac{f_{1.25mm}}{f_{100\mu m}}$ = 5.28 10^{-3} for the SEST sample $\frac{f_{1.25mm}}{f_{100\mu m}}$ = 2.92 10^{-3} for the IRAM. Therefore, on average the detected fluxes must be corrected by a factor greater than 2 (see Fig. 1 panels (e) and (f)).

(2) the second hypothesis considered here takes into account that the millimetric scale length is one third of the optical one: $\alpha_{mm} = \frac{1}{3}\alpha_o$. In this case, we find as mean ratios: $\frac{f_{1.25mm}}{f_{100\mu m}}$ = 2.76 10^{-3} for the SEST sample $\frac{f_{1.25mm}}{f_{100\mu m}}$ = 1.51 10^{-3} for the IRAM sample. In this case a large fraction of the millimetric flux would have been detected (Fig. 1 panels (c) and (d)).

From these simple considerations we have shown that the millimetric fluxes, hence the amount of cold dust in galaxies, are crucially dependent on the size of the objects at millimetre wavelengths.

It is not clear how far we can compare these results with the data obtained by Chini et al. on large spirals (1986). The optical dimensions of their objects often exceed that of the beam width and in some cases this is also true for the chop throw. From this point of view, they could have underestimated to some extent the millimetric fluxes. On the other hand, there is evidence that most of the fluxes reported in the IRAS Point Source and Small Extended Source Catalogues are significantly underestimated for extended objects (see Rice et al., 1988; Young et al., 1989). So, their mean ratio $\frac{f_{1.25mm}}{f_{100\mu m}}$ could have been somewhat overestimated.

The Far-IR Extension of Normal Galaxies

The obvious solution to the problem of estimating galaxy broad-band spectra in the mm range will be to use arrays of bolometers, when available (Cunningham and Gear, 1990), to cover the entire

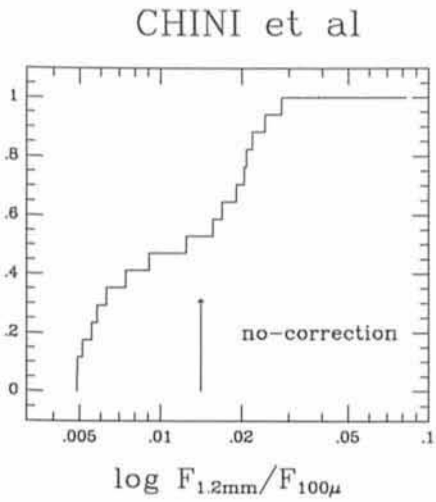

Figure 2: *The same as Figure 1 for the Chini et al.'s results.*

optical extension of the galaxy. The use of large enough beam apertures, some times larger than the diffraction limit, with current mm telescopes is discouraged by the dramatic increase of the sky noise with respect to diffraction-limited observations.

The alternative is to obtain information on the spatial distribution of light emission at submm-mm wavelengths by suitably mapping some bright nearby sources. This will be the goal of our next observing runs at La Silla.

Let us briefly discuss currently available information on the subject.

A direct comparison of optical and far-IR profiles (at $\lambda = 50$ and 100 μm) has been done by Wainscoat et al. (1987) on three nearby edge-on spirals using the IRAS CPC (Chopped Photometric Channel) instrument. Unfortunately, edge-on galaxies do not allow a detailed study of the radial disk structure. However, a comparison between the far-IR emission along the major axis can be performed with the optical old-disk light. From their study of NGC 891 it seems that the 100-μm emission is more extended than the 50-μm one. They suggest that the cold diffuse interstellar component dominates with respect to the optical emission at distances beyond 9 kpc from the centre. For the other two objects (NGC 4565 and NGC 5907) similar far-IR and optical light profiles can be inferred from these observations. This seems to indicate that the cold dust emission at mm wavelengths might be quite extended with respect to the warm component and the optical emission, although IRAS maps at large radii are too noisy for any definitive conclusion to be drawn.

For a sample of large galaxies partially resolved by IRAS (Rice et al., 1988) the mean ratio of the far-IR (60 μm) D_{IR} to blue-light D_B isophotal diameters turns out to be 0.98 ± 0.25, which means that on average galaxies have far-IR extensions comparable to their optical sizes, quite in agreement with previously mentioned results. In this case, however, the observed mean of the ratio of the effective far-IR aperture diameter A_e (which include half of the galaxy's light) to the isophotal radius for 11 objects of this sample, turns out to be almost half of that of the blue light: $< (A_e/D)_{IR} > \sim 0.17$, $< (A_e/D)_B > \sim 0.35$. This difference indicates that the IR emission could be more centrally concentrated than that of the blue light.

A more centrally concentrated mm emission with respect to the optical may be due to the effect of extinction on the blue radiation toward the central regions of the galaxies. This indication agrees with recent reinterpretations of the optical galaxy profiles which seem to show non negligible light absorptions in the galaxy cores (Valentijn, 1990 and 1991; Davies, 1990).

Conclusions

Our knowledge of galaxy spectra in the submm band is still subject to relevant uncertainties. Should galaxy sizes at such wavelengths be comparable, or even larger, than those in the optical light, then mm emission and the corresponding amount of cold dust in the interstellar material would be significantly larger than expected. Detailed observations are planned to clarify this issue.

Several important consequences can be envisaged.

(A) Since the millimetric flux is proportional to the dust mass emitting at these energies, the amount of cold material in galaxies could have been underestimated. This fact could lower the gas-to-dust ratio ($< \frac{M_{gas}}{M_{dust}} >_{spirals} = 570 \pm 50$) claimed for spirals from CO and far-IR measurements (Young et al., 1989), to values comparable to that observed in the ISM of the Galaxy ($< \frac{M_{gas}}{M_{dust}} >_{ISM}$ is roughly 100).

(B) The contribution of discrete sources to the fluctuations of the Cosmic Microwave Background at small and intermediate scales is strongly sensitive to the galaxy spectra in the long wavelength spectral domain (Franceschini et al., 1989). An enhanced thermal dust emission from normal galaxies with respect to current estimates would eventually prevent detections of any intrinsic anisotropies of the CMB.

(C) More precise definitions of galaxy spectral energy distributions and local luminosity function would allow to improve the estimates of number counts and contributions to the diffuse background. Observations by FIRAS on COBE would eventually detect such a background.

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Centrefold
THE ROSETTA NEBULA

The "Rosetta Nebula" is situated just north of the celestial equator, in the constellation of Monoceros (the Unicorn). In its middle is the stellar cluster NGC 2244, one of the youngest of its kind known. The distance to the nebula and the cluster is about 4000–5000 light-years.

There is little doubt that the young stars – they are probably less than 1 million years old – were born in the Rosetta Nebula and have only recently become visible. This is because they have blown away the gas and dust from their immediate surroundings.

The Rosetta Nebula displays a number of dark lanes which are caused by the shadowing effect of dust clouds. Its red colour is caused by the light emission of hydrogen atoms and the different colour hues reflect local variations in the temperature and composition of the nebula.

This photo is a composite from three black-and-white photos obtained with the ESO 1-m Schmidt telescope at La Silla. Observer: D. Block; photographic work: C. Madsen.

New ESO Preprints

(June – August 1991)

Scientific Preprints

771. F.R. Ferraro and G. Piotto: Deep Luminosity Functions of Globular Clusters. IV. NGC 6171. *Monthly Notices of the Royal Astronomical Society.*
772. D. Baade, S. Cristiani, T. Lanz, R.A. Malaney, K.C. Sahu and G. Vladilo: Reduced Upper Limits on the Equivalent Width of Interstellar Li I 670.8 Towards SN 1987A. *Astronomy and Astrophysics.*
773. R.M. West, O. Hainaut and A. Smette: Post-Perihelion Observations of P/Halley. III. An Outburst at R = 14.3 AU. *Astronomy and Astrophysics.*
774. E. Brocato and V. Castellani: Core Overshooting and Stellar Evolution. *Astronomy and Astrophysics* Letters.
775. A. Cavaliere, N. Menci and G. Setti: Distortions of the CMB Spectrum by Distant Clusters of Galaxies. *Astronomy and Astrophysics* Letters.
776. M. Stiavelli, P. Londrillo and A. Messina: Dissipationless Collapse and the Shape of Isophotes. *Monthly Notices of the Royal Astronomical Society.*
777. M. Stiavelli and F. Matteucci: Abundance Gradients and Galaxy Formation. *Astrophysical Journal* Letters.
778. S. D'Odorico, P. Molaro and G. Vladilo: NTT Interstellar Na I Observations of the Two Faint (V ≈ 15.5) Optical Companions of SN 1987A. *Astronomy and Astrophysics.*
779. G. Setti: The Origin of the X-Ray Background. To be published in the proceedings of the 28th Yamada Conference on "Frontiers of X-Ray Astronomy", Nagoya, Japan, April 8–12, 1991.
780. I.J. Danziger, P. Bouchet, C. Gouiffes and L.B. Lucy: Dust and Line Luminosities in SN 1987A. Paper presented at ESO/EIPC Workshop "SN 1987A and Other Supernovae", Marciana Marina, Isola d'Elba, September 17–22, 1990.
781. G. Bono and V. Castellani: A Theoretical Investigation of Population II Red Giant Clumps. *Astronomy and Astrophysics.*
782. A. Iovino, P.A. Shaver and S. Cristiani: The Clustering of Quasars and its Evolution. Paper presented at the Workshop on "The Space Distribution of Quasars", Victoria, Canada, June 1991. To appear in PASP Conference Series.
783. B.E. Westerlund, M. Azzopardi, J. Breysacher and E. Rebeirot: The Evolution of Carbon Stars in the Magellanic Clouds. *Astronomy and Astrophysics Supplement Series.*
784. M.-H. Ulrich, A. Boksenberg, G.E. Bromage, J. Clavel, A. Elvius, M.V. Penston, G.C. Perola and M.A.J. Snijders: The Ultraviolet Spectrum of NGC 4151 from 1978 to 1990. *Astrophysical Journal.*
785. S. D'Odorico, T. Oosterloo, T. Zwitter and M. Calvani: On the Mass of the Compact Object in SS 433. *Nature.*
786. P. Padovani and C.M. Urry: Luminosity Functions, Relativistic Beaming, and Unified Theories of AGN. To appear in the prodeedings of "Physics of Active Galactic Nuclei", June 3–7, 1991, Heidelberg.
787. C.M. Urry, P. Padovani and M. Stickel: Fanaroff-Riley I Galaxies as the Parent Population of BL Lacertae Objects. III. Radio Constraints. *Astrophysical Journal.*
788. D. Baade: Observational Aspects of Stellar Seismology. Invited talk presented at the International Scientific Meeting of the Astronomische Gesellschaft on "Variability in Stars and Galaxies", Bamberg, April 1991. To appear in G. Klare (ed.): Reviews in Modern Astronomy, Vol. 4, "Variability of Stars and Galaxies", Springer, Heidelberg.

Technical Preprints

28. A.F. de Baas and M. Sarazin: The Temperature Structure Function for Complex Terrain. Paper presented at the Eighth Symposium on Turbulent Shear Flows, Technical University of Munich, Germany, September 9–11, 1991.
29. J.M. Beckers: The Use of Differential Adaptive Optics for Astronomical Interferometry. On the Optimization of Partial Adaptive Optics. Submitted as Technical Notes to *Applied Optics.*
30. Th. Rimmele, O. von der Lühe, P.H. Wiborg, A.L. Widener, R.B. Dunn and G. Spence: Solar Feature Correlation Tracker. To appear in *SPIE* Proceedings: Technical Conference 1542 "Active and Adaptive Optical Systems", San Diego, July 22–24, 1991.
31. F. Merkle et al.: Adaptive Optics System Tests at the ESO 3.6-m Telescope. To be published in Proceedings of SPIE, Vol. 1542 (1991).
32. F. Merkle and N. Hubin: Adaptive Optics for the European Very Large Telescope. To be published in Proceedings of SPIE, Vol. 1542 (1991).
33. L. Noethe et al.: Latest Developments of Active Optics of the ESO NTT and the Implications for the ESO VLT. To be published in Proceedings of SPIE, Vol. 1542 (1991).

Professional Video Studio at ESO

During June/July 1991, the ESO Information Service installed a professional video facility (M II format) at the ESO Headquarters in Garching.

ESO has experienced an ever-increasing demand for high-standard video material, in particular from the large TV companies in the member countries, showing various aspects of ESO activities, scientific and technical. Main subjects of interest continue to be the scientific work at La Silla, as well as the NTT and, more recently, the VLT project and the development of Paranal.

The M II format represents the latest video technology and ESO is now able to document its activities fully in "broadcast" standard. At the same time, VHS and S-VHS copies can be made at a minimum of cost, ensuring a quick and efficient distribution of videos from ESO to less demanding customers.

The ESO video team consists of Claus Madsen and Herbert Zodet (in the picture) who from now on will make video recordings of all important events at ESO. Since they are based in Europe and would not be able to travel to Chile at a moment's notice, whenever a special event takes place there, they will be supported by Jürgen Eschwey of the ESO team at Paranal. His first assignment is to record the beginning of the levelling and blasting at the top of that mountain in September 1991.

All enquiries about ESO videos should be directed to the ESO Information Service (address on the last page).

Giotto to Visit Comet P/Grigg-Skjellerup in 1992

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The Mission Background

Shortly after its successful encounter with comet P/Halley on March 14, 1986, which provided a wealth of exciting new data, the GIOTTO spacecraft was put into hibernation with the prospect to reactivate it later on and to retarget it for an encounter with comet P/Grigg-Skjellerup in 1992.

After nearly four years in hibernation the spacecraft was reactivated on February 19, 1990. Subsequently, the check-out of the spacecraft and the scientific payload demonstrated that GIOTTO is in a state to support such an extended mission and that a complement of at least six – of the original eleven – science instruments was functional and able to provide data of high quality during a second cometary encounter.

Science investigation, which can be made with this payload, include:

- characterization of the changing features of the solar wind flow and observation of cometary pick-up ions and anomalous acceleration
- determination of electron densities
- observation of upstream waves, determination of the location of the various boundaries (bow shock, ionopause, cometopause, etc.)
- observation of the magnetic pile-up region and cavity
- determination of the dust spatial density and size distribution and of the optical properties of the dust grains
- discrete gaseous emissions
- combined dust and gas densities

Despite the fact that the Halley Multicolour Camera (HMC) will not provide any images of the nucleus – the aperture of the HMC is blocked most probably by a piece of the outer straylight baffle that has been severely damaged during the close encounter with P/Halley – and that the Neutral Mass Spectrometer had all detectors damaged, ESA's Science Programme Committee confirmed the high scientific value of a GIOTTO Extended Mission at its meeting on June 12 and 13, 1991.

The Orbit

With an aphelion distance of 4.94 AU comet P/Grigg-Skjellerup belongs to the Jupiter family of comets. The perihelion distance of 0.99 AU – together with other characteristics – makes this comet very attractive for an encounter with GIOTTO on July 10, 1992, just 12 days before perihelion passage of the comet. Table 1 contains the most recent orbital parameters of P/Grigg-Skjellerup determined at the European Space Operations Centre ESOC in Darmstadt. The times are ephemeris times ET, the angles are referred to the ecliptic of mean equinox 1950.0 and the definition of the non-gravitational parameters A1 and A2 is that of Marsden et al. (1973). As can be seen from Table 1, the non-gravitational forces are found to be small and perturb the cometary motion only slightly.

The Visibility Before the Encounter

For the forthcoming perihelion passage the visibility of P/Grigg-Skjellerup from Earth starts in July/August 1991 (morning sky). The comet can be observed from both hemispheres of the Earth up to about May 1992. It will stay relatively close to the celestial equator (between +13 and –6 deg declination). The number of dark hours per night is higher for observers located in the northern hemisphere until April 1992 (see Fig. 1). Though the visual brightness of the comet may be rather faint (see Fig. 2), measurements of astrometric positions and physical properties of the comet can certainly be obtained by large telescopes during this time interval.

Within two months before the GIOTTO encounter with P/Grigg-Skjellerup the comet will be observable from the southern hemisphere only. The brightness and activity of the comet will increase towards perihelion passage. However, intensive observations may suffer from both the rather moderate total coma brightness (about 13 mag in the maximum; see Fig. 2) and the small elongation of the comet from the Sun which will result in just one to two hours observing time at low elevation in the evening sky. However, scientific observations, both astrometric and astrophysical ones, collected during this time interval, will be of high importance for the success of the fly-by and the interpretation of the GEM data.

The Light Curve

For most apparitions the visual brightness of P/Grigg-Skjellerup was estimated during about a two-month time interval before and after perihelion passage. Only very little is known about the light curve outside this arc of the

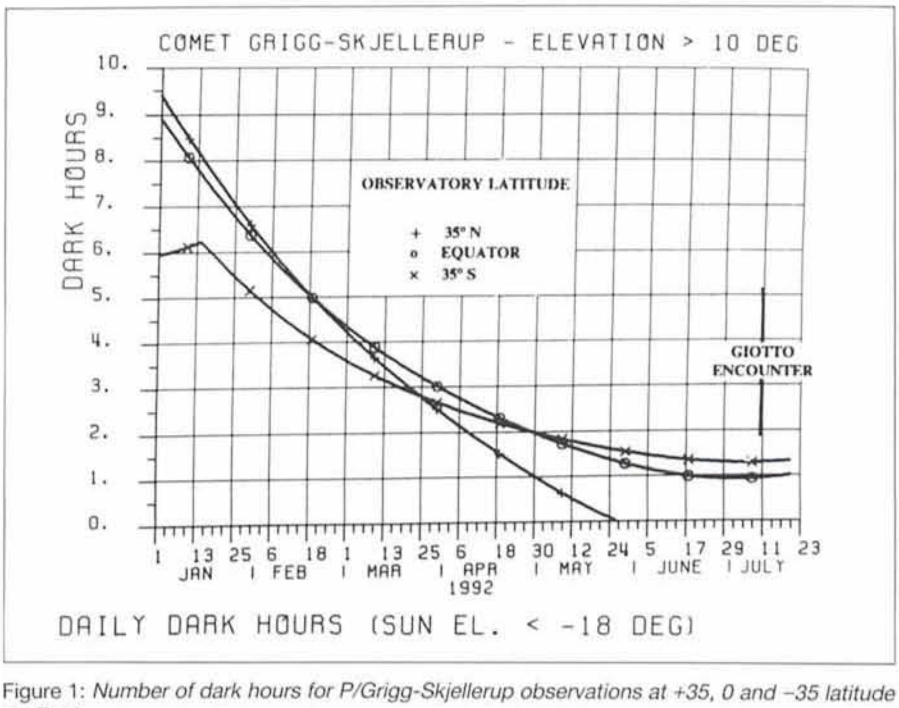

Figure 1: *Number of dark hours for P/Grigg-Skjellerup observations at +35, 0 and –35 latitude on Earth.*

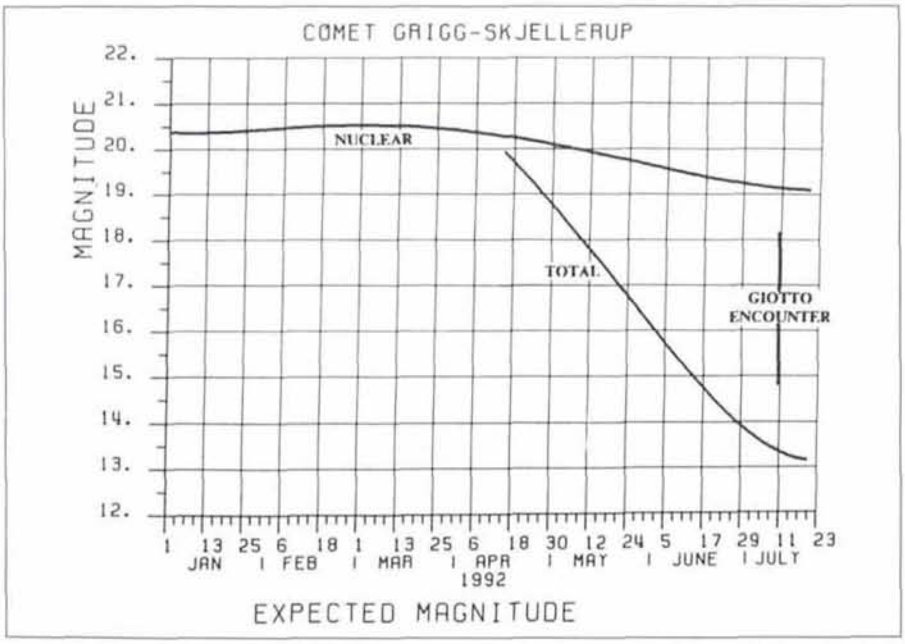

Figure 2: *Predicted nucleus and total coma brightness of comet P/Grigg-Skjellerup in 1992 until the GEM encounter.*

orbit. Some – partly puzzling – measurements of the nucleus' brightness are available from the 1986/87 apparition of the comet. The total and the nucleus light curve of comet P/Grigg-Skjellerup is plotted in Figure 2. The data were calculated from the light curve coefficients published by Nakano and Green (1991).

From the beginning of 1992 until the GIOTTO encounter the nucleus brightness should increase only slightly from about 20.5 to 19 mag. For the total coma brightness a maximum value of about 13 mag can be expected around perihelion passage which is close to the GIOTTO fly-by. The light curve of Nakano and Green indicates that the comet may show a rather late onset of significant coma development and a steep brightness increase pre-perihelion. However, this prediction of the early coma activity may be prone to errors because of the fragmented observational coverage of this phase during previous apparitions.

The Fly-by of GIOTTO

After the encounter with comet P/Halley on March 14, 1986, the GIOTTO spacecraft was put into hibernation, an operations state of minimal on-board activities without control from Earth. In February 1990 GIOTTO was reactivated by ESOC for the first ever swing-by of an interplanetary space probe at Earth. The swing-by was successfully performed on July 2, 1990. GIOTTO was redirected to an encounter with comet P/Grigg-Skjellerup in July 1992. After this trajectory change GIOTTO was again put into hibernation. It will be reactivated in May 1992 for the preparation of the comet fly-by.

Based on the present knowledge of the GIOTTO and P/Grigg-Skjellerup orbits the GIOTTO fly-by at the comet will take place on July 10, 1992 15:25 ±00:10 UT at 1.01 AU distance from the Sun and 1.43 AU distance from the Earth. The relative fly-by velocity will be 13.99 km/s. Figure 3 sketches the pre-encounter approach of both objects together with the respective position of the Earth. The final targeting of GIOTTO for the fly-by will be performed by ESOC about 2 days before encounter at the latest. However, in any case GIOTTO will pass the orbital plane of the comet from North to South during the encounter.

A Request for Astrometry

Comet P/Grigg-Skjellerup was observed during all 13 apparitions since 1922. Because the 1987 apparition was the last one before the GIOTTO swing-by at the Earth on July 2, 1990, which redirected the satellite towards P/Grigg-Skjellerup, ESOC has instigated an appeal for astrometric measurements of the comet to the observers. Altogether 60 accurate position measurements were obtained – more than double the number collected in 1982 and several times as many as at most other apparitions.

In 1992, high-quality astrometry of P/Grigg-Skjellerup is needed at ESOC for the final targeting of GIOTTO towards an optimum fly-by at the comet on July 10, 1992. The importance of ground-based astrometry for the orbit determination of P/Grigg-Skjellerup is even higher than during the Halley campaign in 1985/86 since for GIOTTO there will be no Pathfinder Project (Muench et al., 1986) using observations from other cometary missions. Therefore, ESOC is seeking the direct collaboration with professional observers who are able and willing to obtain astrometric positions of P/Grigg-Skjellerup in 1991/92 before the encounter. The observers should be able

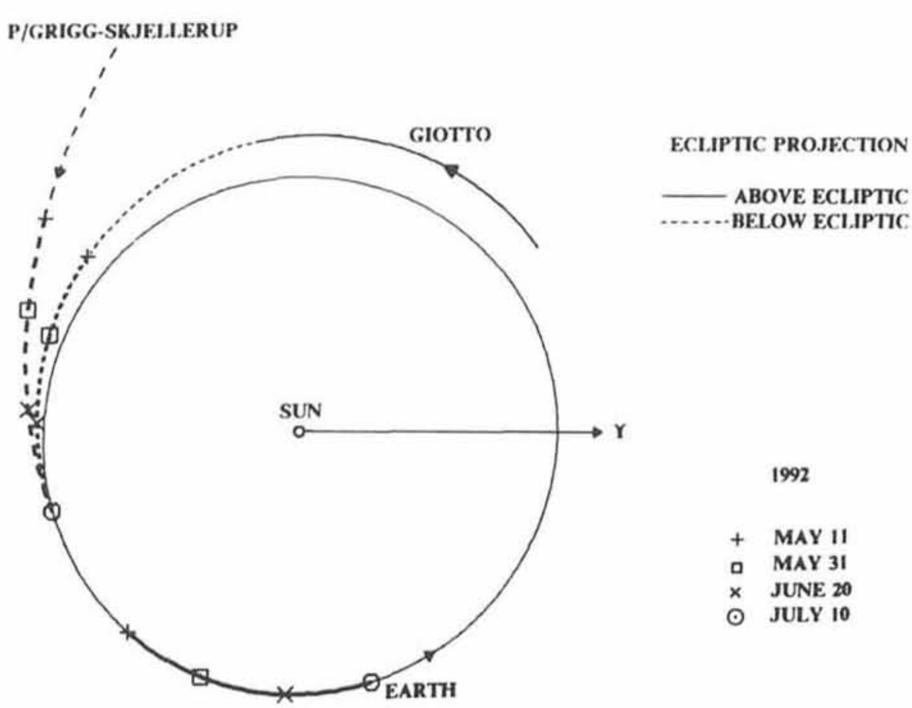

Figure 3: *Orbits of GIOTTO, comet P/Grigg-Skjellerup and the Earth until encounter.*

Table 1. *Orbital Parameters of Comet P/Grigg-Skjellerup*

Epoch	1992/07/10.60226 ET
Perihelion Time	1992/07/22.13729 ET
Perihelion Distance	0.9946892 AU
Eccentricity	0.6643366
Argument of Perihelion	359.27567 deg
Longitude of Ascending Node	212.63159 deg
Inclination	21.10411 deg
Non-gravitational Parameter A1	+0.0153 E-8 AU/day^2
Non-gravitational Parameter A2	−0.0012 E-8 AU/day^2

to communicate the astrometric positions of the comet to ESOC within a few hours to two days after observations in order to allow an immediate update of the cometary orbit for the fly-by planning of GEM. All positions of the comet reaching ESOC before July 8, 1992, will be considered in the planning for the GIOTTO encounter. However, of highest priority for the fly-by targeting are position measurements of P/Grigg-Skjellerup obtained within two months before the encounter. During this period the comet will be best observable from the southern hemisphere though it might be a difficult task since the comet will be faint and close to the horizon. Observations are being planned at ESO La Silla, in collaboration with R. West, who also observed Halley in 1986. For the improvement of the orbit determination accuracy so far unpublished position measurements of the comet obtained during previous apparitions (in particular in 1987, 1982, 1977) are very welcome at ESOC.

Astronomers who are interested to contribute to the P/Grigg-Skjellerup astrometry campaign for the GIOTTO fly-by may contact for further information:

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The Vaca Muerta Mesosiderite

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The lonely Atacama desert is a perfect place to study distant celestial bodies in the space around us. The following story shows how this may be done, not only through powerful astronomical telescopes at isolated mountain-top observatories, but also down on the barren desert plain in a much more direct way.

We have just completed a detailed study of a gigantic, but little known meteoritic impact in a remote region of the Atacama Desert. Over a period of four years we carefully searched a large area in the middle of nowhere and collected seventy-seven specimens of the Vaca Muerta ("Dead Cow") meteorite with a total mass of more than 3400 kg. This meteorite is of the rare stony-iron type (mesosiderite) and our finds have more than tripled the available material of this type which is of great importance for the study of the early history of our solar system. We did this work in our spare time and should like to express our great appreciation for the excellent collaboration with meteorite-oriented scientists in various countries as well as with the Chilean authorities.

Two of us are used to observe remote objects in space, but it was really great fun for once to do down-to-Earth astronomy and to work with our geologist-colleagues!

The Fall of the Vaca Muerta Meteorite

In addition to the large planets and their moons, there are many smaller solid bodies which move in elliptical orbits in the solar system. They come in all sizes, from *minor planets* with diameters above a few hundred metres, to metre-sized *meteoroids* (boulders) and down to microscopic *dust*.

From time to time, a small dust grain from interplanetary space enters the Earth's atmosphere with a very high velocity, often of the order of 10 km/sec or more. It is immediately heated by the friction with the air and begins to glow; this is what we call a *meteor* (a "shooting star"). Such events are very frequent and can be seen on every cloudfree night. More rarely a larger object, even a small boulder, may enter and will then be seen as a bright *bolide*. It leaves a luminous trail across the sky which can sometimes be seen in full daylight. If the boulder is big enough, a part of it will survive the descent through the atmosphere and will hit the ground, where it may be found as a *meteorite*.

About 3500 years ago, a large meteorite with a mass of several tons and measuring at least one metre across fell from the sky over the central part of the Atacama Desert in northern Chile. During its rapid passage through the Earth's atmosphere the big stone disintegrated into numerous smaller pieces which impacted in the desert sand over an area of some 20 km^2. Here they remained in well-preserved condition, due to the extremely dry conditions in the desert.

The fall-zone lies in a very remote part of the desert and most of the meteorite

Figure 1: *This photo shows Harri Lindgren at a miner's depot of fragments from the Vaca Muerta ("Dead Cow") meteorite, just after discovery during a field trip in the fall area.*

This stony-iron meteorite fell about 3500 years ago in the Chilean Atacama desert, at a site about 60 km inland from the coastal city of Taltal and about 100 km from Paranal, the site of ESO's VLT Observatory. The meteorite broke into many smaller fragments, which are spread over a 20 km² area.

Some of these pieces were first discovered by miners in the early 1860's, who thought that the heavy stones contained silver. They collected many of the larger fragments and worked on some of them in order to extract the valuable iron-nickel nodes inside.

The meteoritic stones in the foreground are darker than the other stones in this absolutely barren desert. Some of the miners' stone tools are seen in the background. The darker flakes on the sand indicate that the fragments have been worked on, more than one hundred years ago.

However, most of the seventy-seven fragments of the Vaca Muerta meteorite which were recovered were untouched by the miners.

fragments escaped notice until recently. However, some of them were collected already in the 1860's, when prospectors first travelled through this inhospitable region in search of precious minerals. When they found some heavy masses which became shiny when polished, they thought they had hit upon a silvermine. They collected some stones and brought an unknown number to the mining town of Copiapo, perhaps more than 1000 kg altogether.

Most of this material was probably discarded, but some stones (in total about 45 kg) found their way into mineral collections and were recognized as meteoritic. A few years later this meteorite fall was given the name "Vaca Muerta" (the Dead Cow) after a nearby dry riverbed (Quebrada Vaca Muerta), but soon after, the exact location was completely forgotten.

For more than 100 years, nobody knew where the Vaca Muerta meteorite had fallen. However, in 1985 the site was rediscovered by Edmundo Martinez, following a lengthy study of the old accounts. At that time Martinez was a student of geology at Universidad del Norte, Antofagasta; he still lives there, while he runs a travel agency in San Pedro de Atacama, a small town in the middle of the Atacama desert.

Searching for the Pieces

In addition to a few fragments which had been collected and worked on by miners in the last century (in order to extract the valuable iron-nickel clumps within them), Martinez found one big body which had not been molested. His brother spoke of this discovery to one of us (CdB), and soon thereafter we decided to embark upon a scientific study of the area.

This involved a rather painstaking on-foot search of the fall area, which we found to measure about 11×2 km. The distribution of the recovered pieces indicates that the meteorite entered from East-South-East, i.e. it flew over the high Andes mountains before the impact. One of the largest fragments hit the ground with such a force that a 10-metre crater was excavated to a central depth of almost 2 metres.

In total, we located 77 specimens during ten expeditions to the area between February 1987 and January 1991. Twenty of these pieces had already been displaced and partly worked on by the miners (Fig. 1); this was also indicated by some artifacts from last century which were found nearby, including mining tools, cooking utensils, cans, beer and cognac capsules, corks, horse-shoe nails, parts of boot soles and a coin from 1871. But 57 specimens, ranging from a few grammes to one piece weighing no less than 309 kg, were found in "virgin" condition, i.e. undisturbed since the fall, except for some erosion. Such pieces are particularly valuable for meteoritic studies.

We have now prepared a very detailed, scientific account of this work with the title "Vaca Muerta Mesosiderite Strewnfield" which will soon appear in the international journal *Meteoritics* of the Meteoritical Society, the world's foremost authority in this scientific field.

The Scientific Study Begins

All meteoritic material has now been recovered and is safely kept in Chilean collections, in particular at the Universidad de La Serena and also at the Museo Nacional de Historia Natural, Santiago de Chile. The combined mass exceeds 3400 kg and the meteorite is therefore by far the largest known in its class; this type of meteorite is much more rare than the common stony and iron meteorites.

Detailed laboratory analysis of the Vaca Muerta meteorite has begun and it is slowly unveiling its dramatic story. Its age has been dated by radiochemical methods and mineralogical studies are made of its composition and internal

Figure 2: *Twelve small masses of the Vaca Muerta Meteorite with a total mass of 9.7 kg, as they were found in the Atacama desert. From left to right: Holger Pedersen, Canut de Bon (son), Canut de Bon (father) and Harri Lindgren.*

structure. The time of the fall was determined as 3500 ± 1300 years before present by means of Carbon-14 dating by A.J.T. Jull of the University of Arizona, Tucson, U.S.A. This technique is based on the fact that while the meteorite is still in space, it is continuously bombarded by cosmic rays, leading to a particular internal proportion of Carbon-12 and -14 atoms. As soon as it passes through the Earth's atmosphere, it is shielded from cosmic rays and the proportion begins to change as the radioactive Carbon-14 atoms decay. A measurement of this proportion will therefore indicate the time since the fall.

Some of the minor planets, along with the comets, are thought to consist of material that dates back to the very beginning of the solar system. The minor planet from which the Vaca Muerta meteorite derives is about 4500 million years old and therefore nearly as old as the solar system itself.

The early life of this minor planet was obviously very violent. At some time a partially molten, volcanically active body moving at high speed through the solar system collided catastrophically with a metallic-core minor planet. When the finely intertwined materials cooled and solidified, they formed a cosmic breccia (mixture of minerals) which was half stony and half metallic. Later, after an unknown period of time, this minor planet split into a swarm of smaller fragments, some of which now fall to the Earth at rare moments. One of them was the Vaca Muerta meteorite.

This particular kind of stony-iron meteorite is known from about 30 other locations only. The amount recovered at Vaca Muerta has tripled the material available to laboratory study. When fully analysed, the seventy-seven "dead cows" from Atacama will undoubtedly provide us with much new insight into the enigmatic history of the early solar system.

GPO Observations of a Geostationary TV-Satellite Quartet

H. BOEHNHARDT, Dr.-Remeis-Sternwarte, Bamberg, Germany

1. Introduction

During an astrometry campaign on asteroids a test was performed to observe geostationary satellites with the GPO 40-cm astrograph at ESO La Silla/ Chile. In several nights from April 10 to 22, 1991, spacecraft located at geostationary longitude 19 deg West about 35800 km above the equator were photographed with the GPO. At this longitude in total four telecommunication satellites are operated by three different control centres, i.e. TDF-1 and TDF-2 by CNES Toulouse, OLYMPUS by Telespazio Fucino under contract of ESA and TV-SAT-2 by GSOC/DLR Oberpfaffenhofen.

In order to guarantee the contact with the fixed mounted user antennas on ground, the individual spacecraft have to be kept in control boxes of certain latitude and longitude intervals. The respective control boxes are in inclination below 0.1 deg for all four satellites, in longitude within 18.7 to 18.9 deg West for both TDF satellites, within 18.9 to 19.1 deg West for OLYMPUS and within 19.1 to 19.3 deg West for TV-SAT-2. A violation of these so-called deadbands by one of the satellites may not only cause problems for the users on Earth because of fading signal strength, but may also be a risk for the spacecraft themselves in particular if the longitude window of a neighbouring satellite is entered and a collision of both satellites may occur. Since perturbations from the Earth, the Moon and the Sun cause a geostationary satellite to drift away from its nominal position, the control centres have to correct the orbit regularly both in inclination and in longitude by so-called "station-keeping manoeuvres".

2. The GPO Observations

The geostationary longitude 19 deg West over the Earth equator compares to the telescope coordinates of +4.6 deg in declination and hour angle 3h 52.8 min East for the La Silla observatory. During the about 30-minute time interval of dark-room work per night (in order to change plates for the asteroid programme) old ORWO ZU21 plates found in the refrigerator of the telescope building were exposed with the tele-

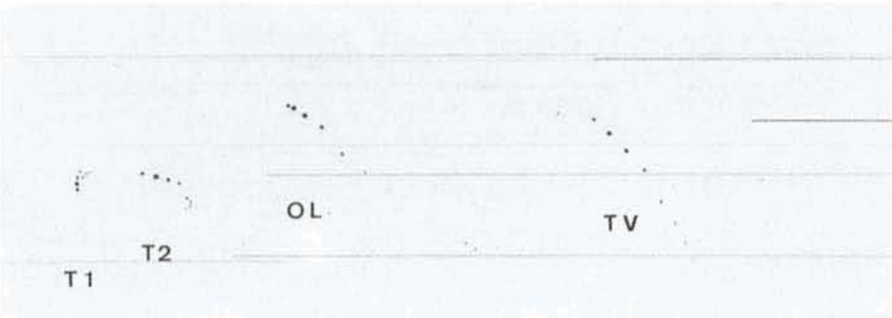

Figure 1: *Multi-exposure of the geostationary quartet at Longitude 19 deg West obtained on April 22, 1991. In total 11 five-minute exposures were taken starting every full hour from 0 UT onwards in order to demonstrate the daily libration of the spacecraft. North is up and East is to the left. The image scale is 0.70 × 0.26 deg. The satellites moved from East towards West during the observing night. T1 = TDF-1; T2 = TDF-2; OL = OLYMPUS; TV = TVSAT-2.*

scope pointing to the geostationary satellites. The telescope tracking was switched off during these satellite exposures. Therefore, on the plates the stars appear as dark lines across the field of view, while the geostationary objects are black dots or short trails (see Figs. 1 and 2; the poor quality of the images is due to the rather old plate material used).

Since the satellite orbits have an inclination usually different from zero and the orbital eccentricity is not exactly zero, the geostationary spacecraft perform a daily libration which is a superposition of a latitudinal, a longitudinal and a radial motion similar to 3-dimensional Lissajous figures. A part of the daily libration of the four satellites is visualized in Figure 1 in projection onto the celestial sphere. This image obtained on April 22, 1991, contains in total 11 five-minute exposures with starting time each full hour. However, only the first nine exposures show the geostationary quartet on the plate. Unfortunately, the telescope moved slightly in declination for a yet unknown reason between exposure 4 and 5 which has introduced an artificial shift of the satellites' motion towards south. For a minimization of fuel consumption geostationary satellites like the 19 deg West quartet are usually operated with perigee pointing approximately towards the Sun. Therefore, the daily longitudinal and radial libration is synchronized, which can clearly be seen in Figure 1. All four spacecraft moved from East towards West during the observing interval.

This picture also illustrates the daily brightness variations of the three-axis stabilized satellites because of the temporal changes in the phase angle Sun-spacecraft-observer. All four satellites are brightest around 1 UT (second exposure), i.e. when the Sun is in "opposition" to the satellites. Furthermore, the

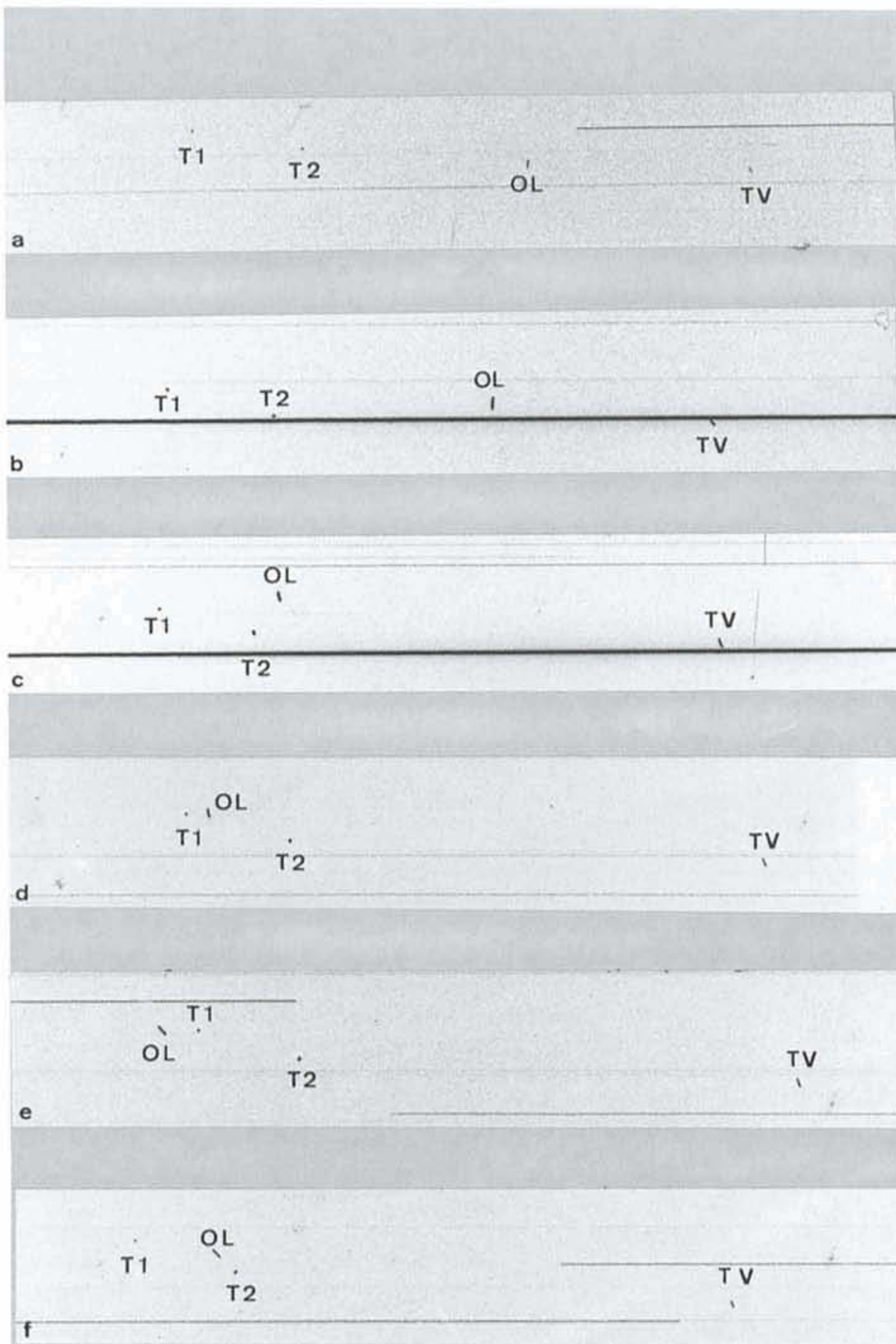

Figure 2: *Sequence of exposures of the geostationary quartet at longitude 19 deg West obtained between April 10 and 20, 1991.*
From April 17 to 20, 1991, a longitude deadband violation of OLYMPUS is documented. North is up, East is to the left. The image scale is 0.70 × 0.12 deg. Satellite abbreviations as in Figure 1.
a: April 10, 1991 06:19:30–06:39:20 UT.
b: April 11, 1991 05:16:00–05:38:00 UT.
c: April 17, 1991 04:43:00–05:03:00 UT.
d: April 18, 1991 05:08:30–05:29:10 UT.
e: April 19, 1991 05:12:00–05:32:32 UT.
f: April 20, 1991 05:40:20–05:59:20 UT.

exposures 10 and 11 obtained at 9 and 9.30 UT, respectively, did not depict the spacecraft at all, probably because most of the satellite surfaces seen from La Silla were in shadow.

3. The Deadband Violation of OLYMPUS

In the sequence of exposures obtained between April 17 and 20, 1991, a so-called longitude deadband violation of OLYMPUS was documented by chance (see Figs. 2a–f). It occurred because of altitude control problems due to onboard sensor errors. For comparison on April 10 and 11, 1991, all four spacecraft were positioned within their control boxes (see Figs. 2a, b). On April 17, 1991, OLYMPUS was already about to pass its eastern longitude limit (see Fig. 2c). It entered the neighbouring TDF control box and can be seen between TDF-1 and TDF-2 on April 18, 1991 (see Fig. 2d), and even east of both TDFs on April 19, 1991 (Fig. 2e). The following day it drifted back to its nominal control box (see Fig. 2f) where it was found inside again on April 22, 1991 (see Fig. 1). Fortunately, this "excursion" of OLYMPUS out of its control box has caused no hazard to the neighbouring TDFs. However, the control centres certainly try to avoid such contingencies during normal operations, in particular for colocated spacecraft like the quartet at 19 deg West.

The astrometric plates obtained on the geostationary satellites can be used to measure the angular distances between the spacecraft. These angles can be transformed into projected inter-satellite distances in kilometers with an accuracy of less than 1 km in geostationary orbit. This is at least of the order or even better than the accuracy of the proximity checks using radio tracking data. Therefore, the optical observations may be useful as an additional check for the orbital proximity calculations of colocated geostationary satellites.

4. Acknowledgement

I like to thank Mr. Rüdiger Knigge of the Dr.-Remeis Observatory, Bamberg, for providing me with the excellent photoprints of the original GPO plates.

Mini-Workshop on Large-Size CCDs at ESO

S. D'ODORICO, T. DUCROS, O. IWERT and R. REISS, ESO

Which is the maximum size of a high-quality scientific CCD detector that industry can now deliver? How can the UV-blue quantum efficiency of the devices be enhanced? What are the best design approaches and the limiting performance of CCD controllers? These questions are puzzling engineers and scientists who have to do with the definition, design and procurement of the detectors and their control systems for astronomical applications. Projects like the instruments for the ESO Very Large Telescope stress the need of devices of large size and state-of-the-art performance in order to take full advantage of the larger collecting area of the telescopes. To focus on these open questions and to obtain a snapshot of this fast developing field, ESO organized on June 18th and 19th in Garching a mini-workshop on "Large Size CCD". Invited were representatives from European groups with a proven experience in this field, a few experts from overseas and speakers of CCD manufacturers with an interest in the astronomy market. The workshop was organized in three sections dedicated to CCD Controllers, CCD Operation/Testing/Design and finally to Presentations from industry. The workshop programme (see box) gives titles and authors of the talks whereas the paragraphs below summarize status and highlights of the various topics, as seen through the (possibly) biased eyes of the authors.

In the field of CCD CONTROLLERS, a variety of systems have been developed at different observatories with the aim of optimizing those operating parameters which are of relevance for the astronomical applications.

The *analog section* of the controller is beside the intrinsic quality of the CCD the dominating part as for what concerns the final quality of the signal processing and the CCD scientific data. The intrinsic CCD read-out noise has been significantly improved in the last years due to the progress in the semiconductor technology and this develop-

PRESENTATIONS AT THE ESO CCD WORKSHOP

- F. Bortoletto, Obs. of Padova: "Activity of the Italian CCD working group"
- J. Bregman, Radiosterrewacht, Dwingeloo: "Performance of CCD controller systems built for the 4.2-m WHT at La Palma"
- P. Müller, University of Bonn: "Flexible CCD Controller for BOCCIA"
- C. Cara, CEA Saclay: "A high performance microsequencer based on logic cell arrays"
- R. Reiss, ESO Garching: "Present and future CCD controllers at ESO"
- A. Blecha, Obs. de Genève: "High level interactive control using the CCD with a small telescope"
- K. Reif, University of Bonn: "BOCCIA: the Bonn CCD imaging and analysing project"
- M. Roth, Munich University Obs.: "Photometric CCD test facility and telescope simulator"
- P. Jorden, RGO, Cambridge: "The operation of large EEV CCDs on the WHT at La Palma"
- J. Geary, Harward Smithsonian Obs.: "Custom design of CCDs for astronomy"
- R. F. Nielsen, Copenhagen University Obs.: "CCD development at Copenhagen University Obs."
- J. Geary, Harward Smithsonian Obs.: "Thinning of Large CCDs"
- G. Weckler, EG & G, U.S.A.: "EG & G Reticon's commitment to scientific imagers – present and future status"
- A. Jutant, Thomson, France: "TMS' CCD production and large CCDs"
- U. Fiedler, Tektronix, Germany: "Status of the Tektronik TK 2048 imagers"
- R. Bredthauer, LORAL, U.S.A.: "Large area astronomical imagers at LORAL"
- P. J. Pool, EEV, U.K.: "Recent developments of CCDs at EEV"

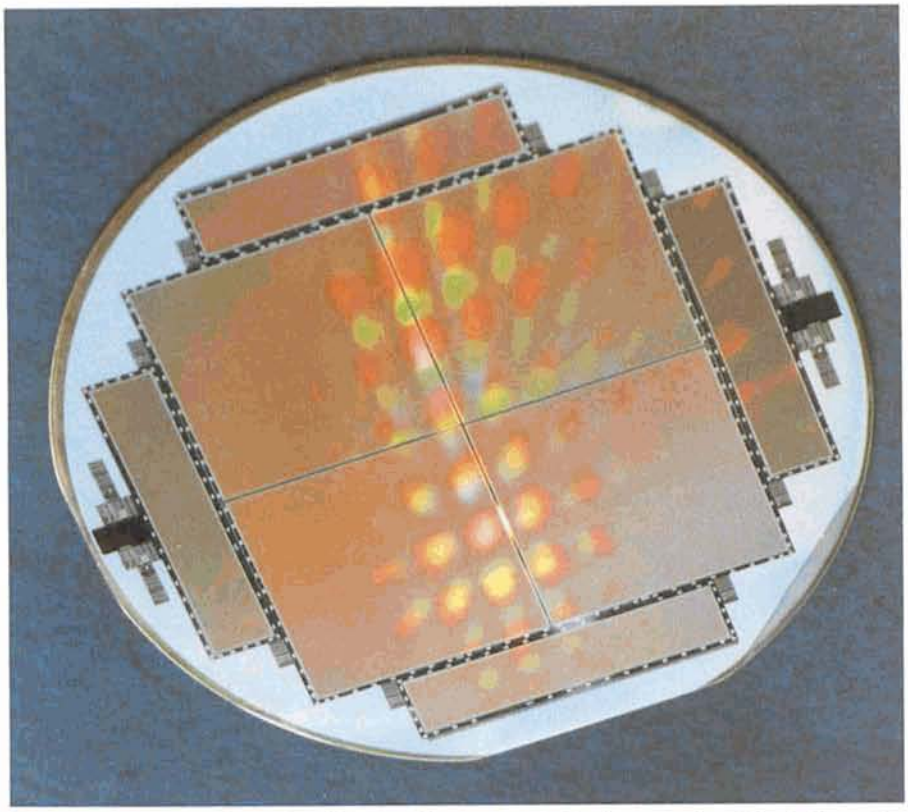

Figure 1: *How to maximize the CCD sensitive area out of a 10-cm wafer: this photograph – courtesy of Ralph Florentin Nielsen – shows a 10-cm silicon wafer by Loral (formerly Ford Aerospace) containing four 2048^2, 15-µm buttable CCDs prior to sawing. The CCD layout by J. Geary of the Harward Smithsonian Center for Astrophysics includes four 2688×512-µm CCDs for spectroscopic applications in the free space of the wafer.*

ment has forced a requirement on the analog chain to be based on circuitry design with a 1 electron equivalent noise. Overall system noise levels of 3–4 electrons have now been reached in optimal operating conditions at various observatories, approaching with CCDs the performance of photon-counting detectors. In spite of various developments concerning *analog drivers* and *video circuitry*, there has been a relative standardization of the principles of the video signal processing. Improvements are still to be expected by the use of improved components and carefully tuning of the analog modules.

Concerning the *digital controller section* the current systems (e.g. the VME-based ESO system) are routinely operating at a good level of reliability. Main disadvantages are their hardware complexity and a high power consumption, besides a great variety of sometimes not standardized interfaces to the host computer. Facing the challenge of telescope arrays like ESO's VLT, the reliability of each CCD system has to be improved drastically in order to ensure the operation of multiple systems at the various foci and telescopes.

A way to reach this aim and to improve at the same time many other features of the CCD control system is the use of Digital Signal Processors (DSPs) and Transputers (TPs) which have become commercially available during the last few years. Basically being a special species of microprocessors, TPs offer an increased capability of standard links to the outside world, e.g. the host computers, a low power consumption and less complexity of the surrounding digital circuitry. Moreover, they can also be used to collect and optionally preprocess large amounts of digital video data. The higher flexibility simplifies the implementation of multiple windows/binning, CCD mosaic operation, and total software control of all static and dynamic CCD voltages. These integrated devices are now established from different companies with standardized interfaces and seem to be well suited in leading to very small, light-weighted and reliable systems possibly attached to the CCD cryostats. Several observatories (RGO, Cerro Tololo, Padova and ESO) have now controllers based on Transputers at various stages of development. Unlike the other groups which are using TPs combined with conventional digital circuitry, ESO currently investigates the use of a combined system of TPs and DSPs. This system aims at combining the interface advantages of TPs and the quick, extremely accurate timing pattern generation of DSPs needed for CCDs.

In the section dedicated to CCD OPERATION/TESTING/DESIGN, the presentations of J. Geary from the Harvard Smithsonian Center provided updated information on two areas of crucial importance. Speaking about "Custom Design of CCDs for Astronomy", Geary pointed out that in the past the design of astronomical instruments had always to adapt to the light-sensitive area format and pixel size of commercially available CCD detectors. The development of custom-designed CCDs with guaranteed performance by the industry results in relatively high costs. Lack of the sophisticated design equipment needed for the work made it impossible for the customers to contribute in an active way to the CCD layout work. Through a collaboration with R. Bredthauer of Loral (formerly Ford Aerospace) a new approach for CCD custom design has now been successfully made, where customer and industry share part of the design and test work as well as the fabrication risk. Due to the repetitive structure of CCD light sensitive areas, the design work of the actual CCD semiconductor layout can be done for a single fraction of the CCD structure by the potential user himself on a commonly used IBM compatible PC with Autocad Software. During this design work it is possible to create or to borrow all the unique structures of the CCD (output amps, bus inputs, pixel cell). Useful is here the cooperation among potential users with their own design libraries. The resulting file is then transferred to the CCD manufacturer now acting more like a simple CCD foundry, who can edit the file with a standard text editor and introduces some replication factors for the repetitive parts (pixels, phase structures). The file (now containing the whole CCD structure) is finally converted into a CAD File for lithography with reticle masks. After the CCD production on the wafers the testing effort is again shared between the customer and the manufacturer, with the latter doing the basic on-wafer electrical testing while the first carries out the time-consuming image and full performance tests. When the wafer quality is high and the manufacturing process clean and well tested, one wafer run can produce a relatively large amount of useful devices at a low cost and with a reasonable manpower investment.

A few runs of custom-designed wafers have been successfully completed at Loral. The Danish CCD group coordinated by Johannes Andersen has shared the costs of one of these runs and is expected to receive the first CCDs by the end of the year. An example of a custom designed CCD wafer is shown in Figure 1.

What is the major drawback of custom designed CCDs? With all their interesting advantages, they remain front illuminated devices with no sensitivity in the astronomically very important UV-blue spectral region. In his second talk at the workshop, J. Geary discussed the problem of CCD thinning and the companies/laboratories who have acquired experience in this field. Various mechanical/chemical processes of whole wafer or single cut CCD thinning have been used with different degrees of success. RCA more than ten years ago, Tektronix, EG&G Reticon, Thomson and EEV in the recent past have all successfully produced thinned devices with enhanced UV-blue sensitivity. Tektronix seems at present to be the only one who regularly masters the process on devices as large as 50×50 mm. Thinning experiments are also carried out at the CCD Lab of Mike Lesser at Steward Observatory, at the lab of Danbury Optical Systems and at the David Sarnoff Research Center. These are potential addresses for CCD customers with a batch of printed wafers to thin, but the rate of success and the cost of the process are still not well defined.

The final session was dedicated to the PRESENTATIONS FROM INDUSTRY. The participants had the opportunity to hear reports on the latest products from most of the major manufacturers of scientific CCDs, as shown in the list of talks on page 43. On the size of CCDs, the trend is clearly dominated by the need to maximize the number of devices which can be fitted on 10 cm wafers to reduce the costs. This explains the success of the 2048^2, 15-μm-pixel format which allows to squeeze 4 devices on one wafer as shown in Figure 1. Improved performance was also reported due to the progress in microchannel technology for a high CTE at very low light levels and the Lightly Doped Drain (LDD) on-chip preamplifier for lower noise and higher gain.

On the performance of CCDs that a potential customer can get now off-the-shelves of industry, we suggest to contact the commercial agents of the companies. As a provisional guideline, we give below a summary of the situation as obtained from our notes on the presentations and the data sheets distributed at the workshop.

EG & G has obtained good results with 1200 × 400, 27-μm-pixel thinned devices and is currently redesigning the chip support for improved flatness.

Thomson CSF has produced thinned devices in the 512^2 format and has made plans to develop a 2048^2, 17-μm-pixel, 3-edge-buttable, thinned device.

Tektronix announced the availability of their 2048^2, 24-μm-pixel, thinned, CCD for July 1991. The device is offered with a guaranteed performance and it appears the only one of this size available on short term. The price was not named at the workshop, but Tektronix is now willing to quote it.

Richard Bredthauer of the CCD laboratory of Loral presented their results on CCDs of different formats, like the 2048^2, 15-μm-pixel and the 4096^2, 7.5-μm devices.

EEV now delivers front-illuminated devices with up to 1242 × 1152 pixels (22-μm size) and has announced a 2186 × 1152 pixel CCD, buttable on two sides. They also obtained good results in thinning smaller devices.

Beside the presentations, the workshop offered many opportunities – including a nice dinner in Munich – to discuss the various topics, and to share know-how and expertise. We have the feeling that the meeting fully met its main goals, providing an updating view of the subject and favouring the collaboration between the different groups and with the industrial suppliers.

The Use of Photography in Astronomy:

Some Thoughts about Schmidt Telescope Wide-Field Work

R.M. WEST, ESO

1. Introduction

During the past decade, a revolution has taken place in the field of astronomical detector techniques, and astronomers all over the world are profiting from new digital devices like CCDs and photon-counting detectors. Indeed, it might appear that photography, previously so widely used in astronomy, will soon be a thing of the past in professional work, no longer of any value in front-line investigations.

Among the various types of ground-based astronomical instruments now in use, none has been more intimately connected to the development of improved photographic methods over the past decades than the large Schmidt telescopes. The future of the photographic detector in astronomy is therefore largely dependent on its useful application at Schmidt telescopes. In this article I shall explore a question that is now being posed at many observatories: is it reasonable to continue to use photographic plates in Schmidt telescopes or has the time come to aim at a rapid implementation of CCD techniques, also here?

In this connection, it should be remembered that *"an astronomical instrument is only as good as the scientific results it produces"*. This maxim is not always kept in mind and around the world there are quite a few examples of "senior" telescopes with associated methodology which for sentimental or traditional reasons continue to be in use, long after it has been shown (in other places) that their ability to produce good science of current relevance has begun to decline. Moreover, it is not always fully appreciated that it is the *science* resulting from an instrument that defines its current value in a global context, not the *technology* it employs.

In addition to the fundamental limitations imposed by the funds available in any one place, there may of course be other, perfectly valid reasons, for instance long-term continuity of observational programmes and the availability of well-established calibration systems, which makes it advantageous to keep using certain telescopes, auxiliary instruments and associated methods, also well beyond their prime years. However, in the ideal case, and certainly for most front-line research programmes, it is clear that failure to adopt new and improved technology and observational methods will eventually result in slower scientific progress and ultimately, in falling behind the rest of the world. It is also a question of the real cost of the observational data – if from a certain moment a new method allows the same astronomical information to be gathered at significantly lower expense in time and manpower, then a change-over ought to be seriously considered.

The question above can then be reformulated: would the introduction of CCD techniques in Schmidt telescopes enhance their ability to produce good science?

The most important, intrinsic properties of the photographic and CCD techniques are compared in Table 1.

Both types of detector demand very careful handling. To ensure the best use of CCDs, it is necessary to obtain bias, flat-field and dark frames, and the elimination of artificial and natural blemishes, e.g. cosmic-ray events, implies time-consuming work which is not necessarily "easier", but perhaps better controllable than the delicate hypersensitization and processing of photographic plates. In this connection, it is an interesting fact that only the photographic emulsion is at the same time detector and storage medium and that therefore the important question of complete archiving of the raw observational data for the benefit of future users is *a priori* taken care of in photography.

On the other hand, the digital output from CCDs is perfectly suited for direct input to computers, thereby streamlining the reduction procedures and, above all, eliminating the need for a preceding transfer from analogue density to digital numbers via more or less noisy registration devices.

It is therefore clear that the main advantages of the photographic plate over the CCD are *its larger size and the ease with which the observed data can be archived.* Within the foreseeable future, no CCDs, not even mosaics, can be expected to approach the field size and thereby also the total information storage capacity of large photographic plates.

But are these advantages important enough to warrant further use of the photographic method in existing large Schmidt telescopes? Would it not, with the shorter exposure times needed, be possible to cover the same total sky field in the same time with multiple CCD exposures? And why should we continue to use photographic methods at large Schmidt telescopes, when the digital detectors are so much more accurate and "clean"?

As we shall see below, a more detailed analysis indicates that *the photographic technique is still superior for wide-field, high angular resolution Schmidt work.*

TABLE 1.

	Photography	CCD
Quantum efficiency	max. 4 %	70–80 % at peak sensitivity
Size (pixels)	$> 20{,}000^2$	max. $2{,}048^2$
Response	non-linear	basically linear
Dynamic range	$\sim 10^3$	$> 10^4$

Comparison of the most important, intrinsic properties of the photographic and CCD techniques (optical region; status 1991; a 15-μm "pixel" size is assumed for the photographic plate, corresponding to 1 arcsec in telescopes of the F = 3-metre class).

2. Current Use of Schmidt Telescopes

All of the world's large Schmidt telescopes (e.g. with aperture above 50 cm) currently rely on the use of large photographic plates, which permit the simultaneous registration of direct images or slitless (objective prism) spectra of objects in sky fields of the order of 5° × 5° or larger, with angular resolutions that in most cases are equal to the instantaneous local seeing.

Schmidt plates are used for a great variety of astronomical programmes. Some of these do not fully take advantage of the large field which is the main virtue of Schmidt telescopes, and could well be carried out with other instruments. There are in the literature many examples of research programmes with photographic Schmidt telescopes which are concerned with individual objects whose small angular dimensions would make them fit into a normal CCD frame. In these cases, it would clearly have been more efficient to use the CCD technique at another telescope, although such an instrument may not have been accessible to the astronomers concerned.

"Narrow"-field Schmidt work will not be further considered here and in what follows, I shall restrict myself to *sky surveys* (coverage of a major part of the sky, often in several colours) and *sky patrols* (repeated coverage of the same part of the sky).

Schmidt plates, whether obtained for large sky surveys or for less comprehensive programmes, and whether originals or high-fidelity copies, serve several scientific purposes, of which the following are particularly important:

- Record for later research (e.g. to check the previous behaviour of an object of current interest)
- Inventory of objects in a particular sky area (e.g. to produce catalogues of all objects with particular characteristics)
- (Optical) identification of objects (radio, X-ray, gamma-ray . . .)
- Serendipitous discoveries (e.g. of minor planets, comets and variable objects)

Astronomical observations, including those made with Schmidt telescopes, provide different types of information (data) which may be classified into a number of natural areas (not necessarily in order of perceived significance):

1. Discovery of new objects
2. Astrometric positions (α, δ) of individual objects
3. Photometric intensities of the radiation I (λ, $\vec{p}$) received from individual objects
4. Detection and characterization of temporal variations in position (μ_α, μ_δ) and intensity (light curves) of individual objects
5. Identification of larger structures and their surface characteristics, including higher-order clustering of individual objects

How well is the wide-field Schmidt photographic technique doing in these areas?

1. Discoveries. There is little doubt that Schmidt surveys in different colours, direct or through an objective prism, as well as Schmidt patrols, constitute one of the most successful techniques of identifying (i.e. discovering) particularly "interesting" new objects, due to the ability to cover large sky fields at high angular resolution and at regular time intervals. A well-known example is the Palomar 48-in Schmidt (Oschin) telescope with which large quantities of peculiar objects have been identified for subsequent, detailed studies with the 5-m Hale telescope. Most new minor planets and a large fraction of the new comets are still found on Schmidt plates and all major surveys of particular objects, e.g. emission-line stars, planetary nebulae, galaxies and galaxy clusters, continue to be based on Schmidt plates. Some discoveries also include the archival use of Schmidt plates; a recent example is the identification of the progenitor of the bright supernova 1987A in the LMC with a surprisingly blue colour and early-type spectrum; this "observation" had a direct impact on model calculations of late evolutionary stages of heavy stars.

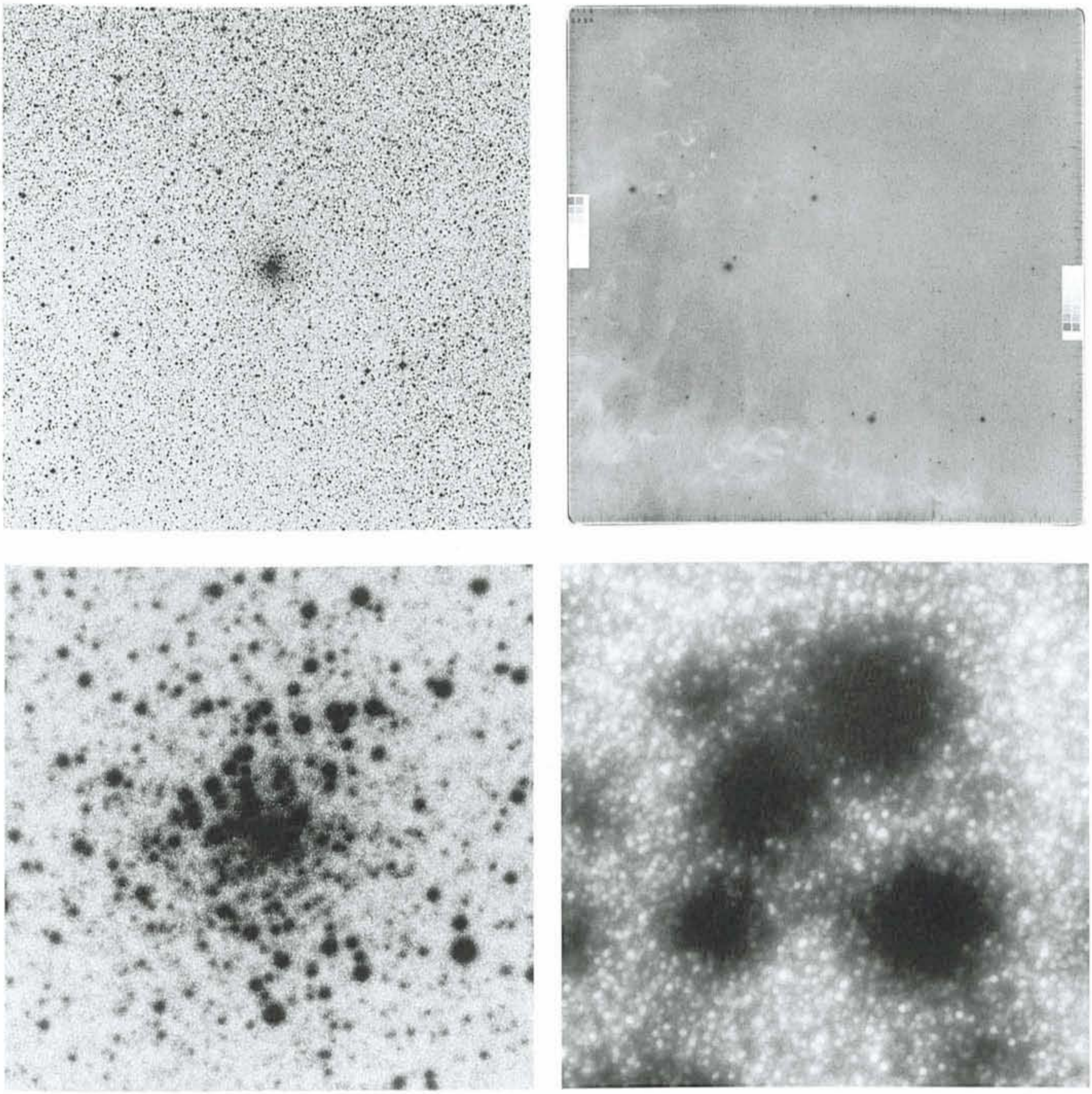

Figure 1: *The enormous amount of information contained on a single Schmidt plate is illustrated by these four images, which were reproduced from an exposure of a sky field in the Milky Way band, obtained with the 1-metre ESO Schmidt telescope on a red-sensitive emulsion (Plate 5714; ESO/SRC field 519; 120 min; 25 July 1984; seeing ~ 1 arcsec). The full plate measures 30×30 cm (upper right) and covers a sky area of 5.6×5.6 degrees. The other three images (counterclockwise) are 3.6×, 36× and 360× enlargements of an area near the globular cluster NGC 6325, seen above the centre of the plate. The field edges measure 1600, 160 and 16 arcsec, respectively; and the total plate area corresponds to 160, 16,000 and 1,600,000 such fields. The limiting magnitude of this ESO(R) plate is about 22. Observer: O. Pizarro. Photographic work: H. Zodet.*

2. Astrometry. Due to the absence of an all-sky, accurate astrometric net with sufficient density for CCD work (~ 1 star per square arcmin) – the HST Guide Star Catalogue may be well suited for guiding purposes, but not for astrometry at the sub-arcsecond level – the only existing method for the determination of accurate astrometric positions of objects too faint to be observed with meridian circles is to use Schmidt plates on which a sufficient number of bright astrometric standards are visible. The absolute position of a faint object (e.g. in the FK5 system) must either be measured directly on a Schmidt plate or, if it is only visible in a narrow-field, deep CCD frame, by transfer of local secondary standards from a Schmidt plate to the CCD field.

3. Photometry. Absolute photometric accuracies of the order of ± 0.07 mag can normally be achieved on well-exposed photographic plates for point-like objects which are at least 3 mag above the plate limit. It is possible to improve this value somewhat by having many photometric standards in the immediate area, but the intrinsic non-linearity of photography and the need to establish a unique intensity calibration for each plate restrict the ultimate level of precision. This compares to ± 0.01–0.02 mag in good CCD frames (total counts per object > 10,000) and illustrates an important limitation of the photographic method. However, the possibility to measure on the same plate a very large number of objects makes Schmidt photometry ideal for statistical investigations which do not demand the highest accuracy.

4. Variability. Photographic Schmidt exposures are a rich source of discovery of variable objects and a base for many long-term variability studies. They include photometric variability of quasars over many decades, the large-scale investigation of variable stars in selected Milky Way fields and, in particular, the identification of faint, high proper-motion objects, e.g. white dwarfs. So far the variability has most often been established by the use of blink comparators, but more recently automatic methods (computer-"blinking") have begun to produce important results.

5. Large Structures. The identification and study of large structures, like Milky Way cirrus and clusters of galaxies at intermediate distances, is obviously facilitated by the availability of wide-field exposures. The importance of all-sky work is amply illustrated by the scientific impact of satellite observatories like IRAS and ROSAT; it has a direct bearing on the study of the largest structures in the Universe and its evolution. While the CCD technique lets us study the finest details in individual objects, the establishment of large samples with clean definition criteria is only possible with wide-field instruments. When combined with the high angular resolution and comparatively faint limiting magnitude of present, large Schmidt telescopes, it is also possible to observe at the same time smaller details within larger structures; some examples are the overall structure of the Gum Nebula, the intricate network of thread-like nebulae in the area of η Carinae, and the complex of interstellar reflection nebulae, near the south celestial pole. In this connection must also be mentioned the objective prism technique, which makes it possible to obtain large numbers of spectra of stars and small nebulae simultaneously and which is unsurpassed for deep studies of the overall stellar distribution in the Galaxy.

In summary, it is obvious that photographic wide-field observations with Schmidt telescopes play an important role in current front-line observational astronomy and would also continue to do so in the near future.

3. Limitations of the Methods

It is now of interest to look more closely at the critical limitations which are inherent in the two types of detectors in order to better judge how the introduction of a CCD into one of the existing large Schmidt telescopes may influence its observational potential.

It is important to emphasize that here it is not the question of installing a small CCD chip into a large Schmidt telescope; this would immediately rob it of its unique wide-field capability, the importance of which has been demonstrated above. Nor is it likely that it would be technically feasible to have a dual system, with the possibility to change between large plates and the CCD camera and its cooling system. The mechanical adjustment of a large Schmidt telescope is extremely critical and frequent exchanges would most certainly lead to inferior performances. Present Schmidt telescopes are obviously optimized for photography, but it would of course be interesting to construct smaller, intermediate-field instruments which are optimized for the largest available CCDs.

3.1 Photography

Regular users of Schmidt telescopes are well aware that in wide-field work, the quality and the astronomical value of the photographic plates depend on a very large number of factors, not all of which can be fully controlled. In the case of sky surveys, of which those in the northern (Palomar) and the southern sky (ESO and UKST) constitute the most comprehensive observing programmes presently undertaken with photographic Schmidt telescopes, the quality of the final product, i.e. the Atlas copies, is among others influenced by the seeing, the mechanical performance of the telescope, the processing and copying of the plates and the archival conditions.

Lack of technological progress. Perhaps the most serious problem in present-day astronomical photography is that for quite a few years, no new, improved emulsions have become available; the latest major advance in the photographic field was the introduction of the IIIa emulsion in 1970, followed some years later by the TP-2415 emulsion. Likewise, most of the photographic techniques which are now in use were already fully developed more than 10 years ago. Thus the field of astronomical photography, in the technical sense, is in a period of stagnation, with correspondingly little incentive to new investments in photographic techniques by the observatories. This is also reflected in the decision not to include any photographic equipment in the new generation of super telescopes, for instance in the ESO 16-m Very Large Telescope, even though the large focal fields could only be fully covered by a photographic plate. The use of multiple-slit techniques, e.g. in the planned fibre optics spectrographs, will only permit the simultaneous registration of a minuscule fraction of the light that is collected and focussed by the telescope.

Extraction of information. Next, the extraction of information from photographic plates has always been a bottleneck in Schmidt work. However, there are positive developments. During the past years, it has been increasingly realized that photographic plates contain a greater wealth of information than thought before, and that their potential has not been exhaustively exploited in the past. This is demonstrated by the impressive results obtained with the photographic amplification, masking and stacking techniques which now make it possible to recognize and measure extremely faint objects which cannot be perceived by direct, visual inspection or even by microphotometric measurement of the plate. At the same time, much effort has been put into improving the extraction of data from photographic plates by means of fast scanning microphotometers, but there are only a few devices in the world in the technological front-line which are also in regular use. Main areas of future improvement are increased speed and extension of the dynamical range by means of better sources of illumination and faster A/D converters.

Archival storage of photographic plates. Photographic plates are stored under very different conditions at the world's observatories. While some plate vaults have advanced climatic control, in other places plate libraries form part of book libraries and the plates are therefore subject to variable temperature and humidity. Old envelopes are often dangerous to plates, since they contain traces of bleaching and/or colouring agents. It is unfortunately also true that not all plate archives profit from an associated efficient retrieval system and at some observatories there is no access to the plates for outside researchers.

In this connection, there are interesting developments which aim at the digitization of existing photographic sky surveys, although it is not yet technically possible to store the complete information of a major sky survey in digital form at an affordable cost. However, the availability of computer-readable digital copies with less resolution and smaller dynamical range than the original survey plates will be very useful for many purposes, e.g. the preparation of finding charts for observations.

3.2 CCDs

When compared to photography, the main drawbacks of the CCD technique are the smaller frame size and the archival problems, while the total cost may play a smaller role.

Field size. The currently largest CCDs in common use in astronomy have 2000 × 2000 pix^2 fields. 4000 × 4000 pix^2 arrays have been experimentally tested but it will still be some time before a reasonable number become available. It seems realistic that mosaics of up to four 2000 × 2000 pix^2 CCDs may be available to observers in five years time. Such a device would cover about 1/25 (~ 1° × 1°) of the Schmidt field. With the present sensitivity ratio (e.g. 75 : 3), the total CCD exposure time necessary to cover the same field to the same limiting magnitude as one photographic plate would be similar; this however, does not take into account the non-negligible read-out time (probably 25 × 2 to 3 min) of the enormous data quantities. The curved focal field in present Schmidt telescopes may be another obstacle. In the ESO f/3 Schmidt, the focal position is critical to within ~ 10 μm, compared to a curvature of ~ 25 μm from the centre to the corner of a 3 × 3 cm^2, 2000 × 2000 pix^2 CCD chip; this may necessitate the insertion of a field flattening lens. The proper recombination of the individual frames into a larger unity, when needed, may also constitute an added difficulty.

Archiving. Probably the most serious problem is that there is still no cheap, universally available storage medium for CCD data. Magnetic tapes are still used in most places to provide a temporary record of raw CCD data and the rapid accumulation of these tapes, in particular because most CCD exposures are comparatively short, is of major concern in many places, including the European Southern Observatory. Unless the tapes are transcribed to a more stable medium, e.g. optical disks, it must be feared that a significant fraction of the valuable data will become unreadable and therefore lost within a few decades. Also the long-term stability of optical disks is still relatively unknown. The problem of organizing and retrieving information in a data base of several Tbytes should not be underestimated either.

Cost. A complete, top-quality CCD system for use in astronomy implies a capital expense that may exceed US$ 100,000, and therefore be beyond the financial reach of most smaller observatories. A CCD can of course be used to obtain an unlimited number of frames, and when the total costs are calculated, the need for archiving of the CCD data must also be taken into account. This involves the time-consuming transfer to the final storage medium and the cumulative cost of magnetic tapes and/or optical disks as well as the associated computer hard- and software. Although in photography the capital investment at the telescope and in the plate processing laboratory may be smaller than the above figure, the total costs are not necessarily so. The 1991 price of one 14 × 14 inch spectroscopic plate is below 100 US$, but in recent years Kodak has repeatedly increased its prices for astronomical emulsions. For a qualified astronomical exploitation of the plates, it is furthermore necessary to acquire (or have access to) a fast measuring machine and a photographical laboratory equipped for advanced plate manipulations.

Conclusions

In summary, it appears that *the photographic technique has virtues which make it better suited than CCDs for wide-field, high-angular resolution Schmidt telescope work, at least until further notice.* Notwithstanding the shortcomings of the photographic plate, its large size and archival properties make it indispensable for the permanent recording of large sky areas during optical sky surveys and patrols. As mentioned above, there is a great current interest in all-sky work and the intimate collaboration between such instruments working in different wavebands, on the ground and from orbiting satellites, is absolutely necessary for the study of the largest structures in the Universe and therefore of its evolution.

For more than 100 years, the photographic technique has guaranteed a continuous record of the visible sky, of

Figure 2: *An astronomical plate archive. Each cupboard in the ESO plate vault at the Headquarters in Garching contains up to 1,500 Schmidt plates. The plates have been processed to the strict ANSI archival standards with a minimum content of residual active silver in the emulsion. The temperature and the humidity in the vault are strictly controlled, and accelerated aging tests indicate that the images on these plates will remain virtually unchanged during many centuries. It is, however, likely that they will be digitized some time in the (not very near) future, once sufficiently compact and equally stable storage media for digital data have been developed. Photograph: H.-H. Heyer*

immense and lasting value for astronomical research, now and in the future. Sky surveys and patrols must continue, lest future generations of astronomers will blame us for not having done our historical duty. When carefully processed and properly stored, photographic plates can last for centuries, while there is at the present no guarantee that even a fraction of the many CCD frames obtained during the past ten years will also be accessible, say, 100 years from now.

It must be stressed that the present conclusion does not apply to work at lower angular resolution and with smaller instruments; there are several examples of the great utility of wide-angle CCD work, for instance the extensive monitoring of Comet Halley's CO^+ tail with a 640 × 1024 pix^2 camera at La Silla in 1986. *It would be highly desirable in the future to complement large Schmidt surveys with very-wide field patrol exposures by specialized low-resolution CCD cameras.*

There is little doubt that CCDs and other digital detectors will ultimately replace the photographic plates in all instruments, and also in the large Schmidt telescopes. But this step should only be taken when these detectors have become big enough not to compromise the efficient and exhaustive exploitation of the unique scientific capabilities of wide-field Schmidt work and when the CCD archiving problem has been satisfactorily resolved.

Acknowledgements

I am very thankful to Martin Cullum, Bo Reipurth, Massimo Tarenghi and Edwin Valentijn, who suggested a number of important improvements to this article.

CASPEC's New Look

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1. Introduction

CASPEC, the 3.6-m Cassegrain Echelle Spectrograph, is one of the 4 high-resolution (HR) spectrographs presently available at La Silla. Together with the EMMI high-resolution mode, CASPEC is the only HR spectrograph capable of reaching relatively faint objects and, thanks to the crossdispersed orders, to record large wavelength ranges (up to 1400 Å in the present configuration) in only one frame. Since the high-resolution mode of EMMI is available in the RED arm only (i.e. for wavelengths redder than 4000 Å) CASPEC will probably remain for the next years the only HR spectrograph available at La Silla capable of reaching faint objects in the BLUE and in the near UV. Recently it has been successfully used at wavelengths as blue as 3130 Å (Baade and Crane, 1991).

ESO has started a programme to upgrade the instrument in order to increase the performance of CASPEC; we report here the recent improvements and we anticipate some of the changes foreseen before the end of the year. For a general description of the instrument the reader is referred to the ESO CASPEC Operating Manual (Pasquini and D'Odorico, 1989).

2. The New Detector

Since September 1990 a new detector is available for CASPEC: it is a 512 × 512 Tektronix chip (ESO CCD 16), with a pixel size of 27 × 27 μm. Its characteristics and response curve are given in Figure 1 (Sinclaire, 1991).

This chip is in several aspects much better than the old RCA 8, previously mounted on CASPEC; in particular:

- It has a larger format, which allows a wavelength coverage up to ~ 1400 Å in one frame.
- It has a lower Read-Out Noise (RON) (~ 10 e^- compared to ~ 28 e^-). This greatly increases the instrumental performance for low S/N observations, where the RON is the dominant source of noise.
- It has a very good cosmetic, no offset columns and no interference fringes; all these characteristics are essential for the correct reduction of Echelle data.

The efficiency of CASPEC with the 31.6 lines/mm echelle plus short camera and CCD 16 was measured through wide slit (4 × 4 arcsec) observations of the standard star Feige 56 (Stone, 1977); results are presented in Figure 2. We note that, in order to compute the data points of Figure 2, the echelle orders were not merged: electrons at wavelengths appearing in more than one order were measured separately and then added up.

The CCD response curve shown in Figure 1 was obtained after UV flooding, a procedure which enhances the detector sensitivity at wavelengths below ~ 4300 Å. When the efficiency tests were performed, the UV-flooding was not properly working; as a consequence, the points of Figure 2 in the Blue and UV ranges must be considered only as lower limits to the real instrumental efficiency.

The points of Figure 2 must be taken as indicative only, because when considering a real science exposure, possible slit losses must be taken into account. With this configuration, however, these losses are not expected to be very important; in fact, a good spectral sampling (2 pixels FWHM) is obtained with a slit width of ~ 300 μm, which corresponds to 2.12 arcsec on the sky. This aperture is much wider than the typical seeing registered at the 3.6-m telescope.

In Figure 3, the expected S/N per pixel as a function of the integration time and the stellar magnitude is shown (continuous lines). In our calculations the stellar light was considered to spread over 3 pixels in the direction perpendicular to the dispersion (one Tektronix pixel corresponding to 0.648 arcsec in the sky with the short camera) and an airmass equal to 1. We fixed the CCD RON to 10 e^-/pixel (instead of the nominal 8.8) because this value seems to be the most common at the telescope.

In Figure 3 are also plotted similar curves computed for the RCA (dashed lines, Pasquini and D'Odorico 1989); despite the lower quantum efficiency of the Tektronix with respect to the RCA, its bigger pixel size and lower RON allows to reach fainter objects.

The new chip, on the other hand, suffers some limitations, the knowledge of which is important for the users:

- The 27 μ pixel size limits the maximum achievable resolving power to R ~ 18,000 with the Short Camera.
- With the Long Camera a resolving power almost two times higher can be obtained, but with no order overlap. In such a configuration, in fact, the portion of the spectrum covered by each order is only 46 % of the wavelength ranges reported in the Thorium-Argon reference spectrum (D'Odorico et al., 1987). By tilting the crossdisperser it is possible to observe any portion of the orders (i.e. not necessarily the central part), but this adjustment can be made only in the afternoon, during the set-up procedure and it cannot be changed by the observer during the night.

• After saturation the CCD shows some remnants, which may last up to a few hours: special care (in particular in taking flat fields) should be used in order to avoid overexposure.

3. Filters

Partially related to the installation of the new chip is the choice of the filters now inserted in the filter wheels:

Neutral Density (ND) Filters: because the internal quartz lamp used for Flat Fields is rather red, it was impossible to obtain low- to intermediate-level flat fields for wavelengths above ~ 5500 Å with the filters previously used. We have therefore inserted a higher density filter; Table 1 displays the new ND wheel configuration.

Colour Filters (CF): Three new colour filters were inserted, mostly to facilitate flat fielding in the BLUE and in the UV. The response curves of the available colour filters are shown in Figure 4. The new CF wheel has the following configuration:

Filter 1: (RG630, unchanged): It is a Long-Wavelength Passband (LWP), to be used for Th-Ar exposures at wavelengths longer than 6250 Å in order to avoid possible contamination from second-order strong lines.

Filter 2: (DG530, unchanged) As filter 1, but with a cut-off at 5350 Å.

Filter 3: (BG24) This filter is particularly important for Flat Fields at central wavelengths between ~ 4000 and ~ 5000 Å: it lowers the instrumental response in the red part of the spectrum, avoiding a too strong intensity gradient between the bluest and reddest orders.

Filters 4 and 5: (UG5 and BG3) As filter 3, but used for bluer wavelengths.

Colour filters can also be inserted in front of the rear-slit viewer and of the small-field cameras. Those filters are mostly recommended for observations in the UV and in the INFRARED in order to avoid miscentring due to the differential atmospheric refraction. The TV cameras have a spectral response peaked in the visible part of the spectrum. These filters can be used only on relatively bright sources. For these observations and for observations requiring very precise positioning of the object

TABLE 1: *New ND wheel configuration.*

Wheel position	*Neutral density*	*Colour filter*
1	*2.22*	*RG 630*
2	*1.91*	*OG 530*
3	*1.37*	*BG 24*
4	*0.87*	*UG 5*
5	*0.51*	*BG 3*

Chip Characteristics

Type:	Tektronix TEK 512M-12, thinned, backside illuminated.
Serial Number:	1215-3-8 (806-7468-71).
Format:	512 × 512 pixels, 50 pre-scan pixels in the horizontal direction.
Pixel size:	27 × 27 microns.
Image size:	13.8 × 13.8 mm.
Conversion factor:	Normally used at 1.7 e^-/ADU (Gain 20, HCK=12 on Gen V Camera).
Noise level:	app. 8.8 e^- RMS at Gain 20 (HCK=12).
Linearity:	Better than ± 1 %. CCD saturation is about 100,000 e^-/pix.
Blemishes:	There are 3 parallel traps to be mapped.
Dark current:	The mean dark is app. 12 e^-/pix/hr at 180 K.
Charge Transfer Eff.:	Measured CTE is 0.999993 in both directions (i.e. 99.3 % after 1000 transfers).
R.Q.E.:	Measured at 180 K. See below.
Operating temp.:	180 Kelvin.
Cosmic Ray Events:	2.9±0.3 events/min/cm^2, i.e. app. 333 events/hr for the entire chip.

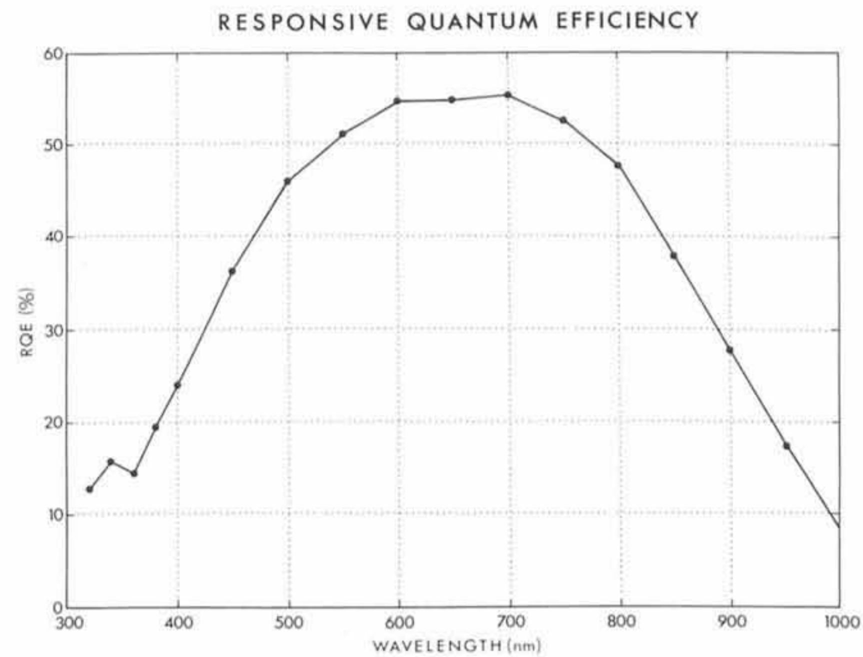

Figure 1: *CCD 16 characteristics and response curve.*

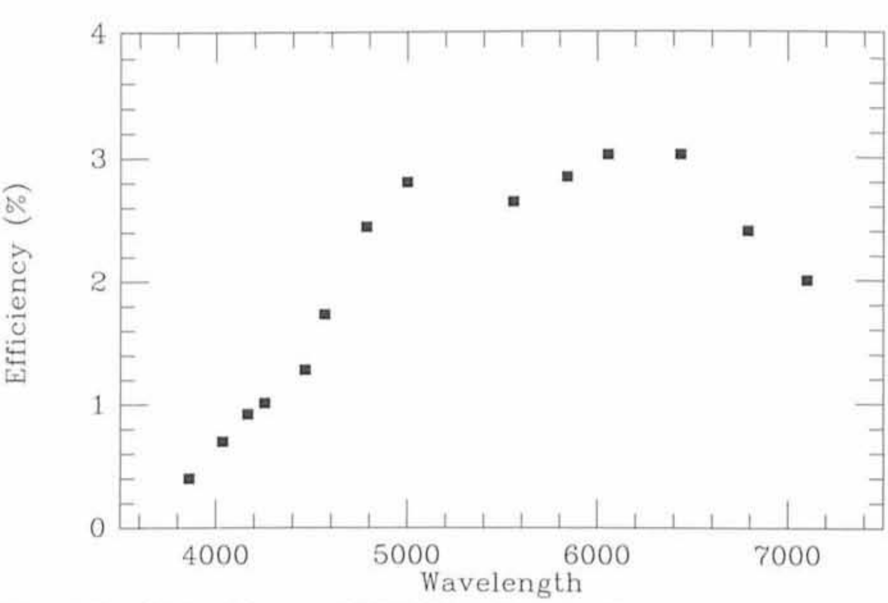

Figure 2: Overall 3.6-m telescope + CASPEC (Short Camera and 31.6 lines/mm echelle) + CCD 16 efficiency curve.

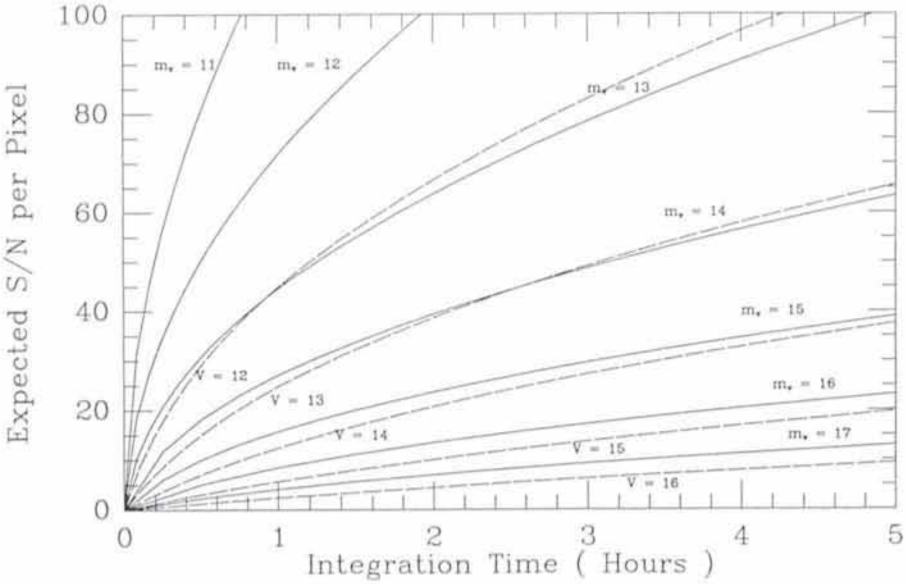

Figure 3: *The expected S/N ratios per pixel at 5556 Å as a function of exposure time for stars of different magnitudes. Continuous lines and m_v refers to the Tektronix chip; dashed lines and V symbols to the RCA. The stellar light was considered to spread over 3 and 4 pixels respectively in the direction perpendicular to the dispersion; pixel size is 27 × 27 μm for the Tektronix and 15 × 15 μm for the RCA.*

in the slit (i.e. accurate radial velocities) it is strongly recommended to orient the slit along the parallactic angle.

4. Shifts

It has been known for a long time that CASPEC presented rather pronounced shifts, which were evident whenever the position of the telescope in the sky was changed and during long exposures on faint objects. These shifts were mostly evident in the direction perpendicular to the dispersion and they produced a degradation of the data, spreading the spectrum over several pixels and lowering the effective S/N. These shifts were caused by the servo controlling the crossdisperser; several solutions were attempted and finally a mechanical counterweight has been applied (courtesy of J.L. Lizon).

Tests using calibration-lamp spectra taken at several telescope positions were performed and they showed that the instrument is now very stable (see Fig. 5 for an example). Long exposures on faint sources have confirmed that this problem is now solved.

In order to allow the counterweight to work, the crossdisperser function must be disabled via software; the procedure is described in the CASPEC Manual (Pasquini and D'Odorico, 1989).

5. Maintenance

CASPEC is a rather complex instrument: it has several moving parts, all the functions are remotely controlled, giving the possibility to change central wavelength and resolution in few minutes; two echelles and two cameras are presently available. Maintenance of such an instrument is therefore a major task. In addition to the regular maintenance, which includes cleaning of the slit jaws, checking and cleaning of all the functions and a new optical alignment, all the mechanical parts close to the beam area were painted black, in order to avoid spurious reflections. This has solved the problem of scattered light affecting the 2-3 bluest orders that appeared when the new CCD (which covers a larger area with respect to the RCA) was used with the 52 lines/mm echelle. New baffles were finally added, in order to make the spectrograph light tight.

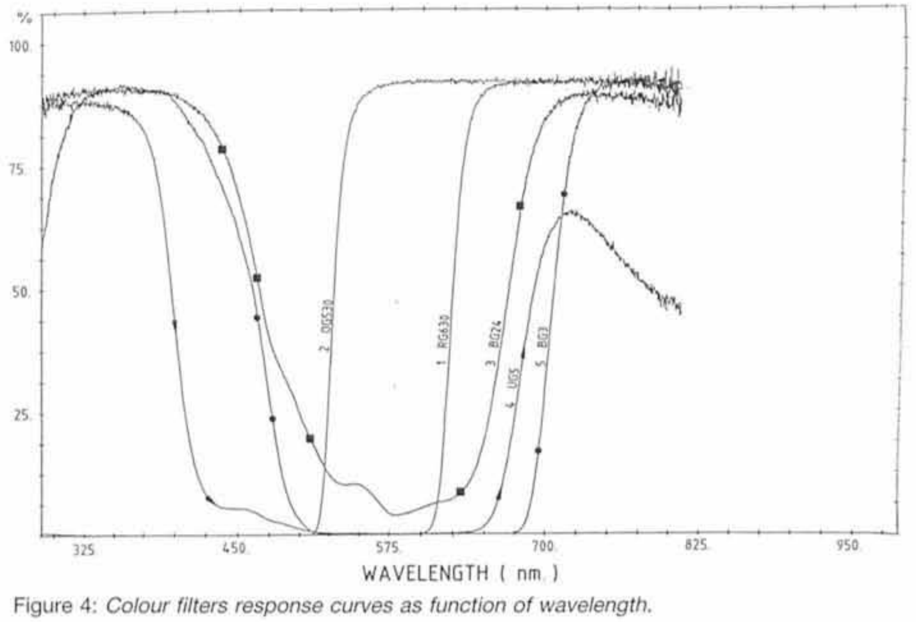

Figure 4: *Colour filters response curves as function of wavelength.*

Despite the baffling, external light can still penetrate into the spectrograph in presence of a strong source; observers are therefore recommended to switch off the lights in the 3.6-m cage when doing calibrations and dark exposures.

The efficiency of the crossdisperser was checked by observing a standard star at 5050 Å. It was found to be very close to the manufacturer's specifications, indicating that no degradation has occurred since the first installation of the instrument.

6. Future Improvements

Despite these improvements, some work is still necessary in order to fully exploit the potential of CASPEC and to make it more user friendly; some implementations, concerning a better design of the Rear Slit Viewer, the driving software and the change of some optical parts, are under study.

The first step will consist in the installation of a new RED crossdisperser in the coming months. This crossdisperser will enhance the performance of CASPEC for wavelengths longer than ~ 5500 Å, giving a better match between the spectrograph and the chip characteristics. In fact, despite a good quantum efficiency of the Tektronix in the red, the final CASPEC performances are limited in this spectral region by the poor response of the present crossdisperser (Fig. 2.3 in Pasquini and D'Odorico, 1989).

Acknowledgements

We are grateful to J.L. Lizon, G. Ruprecht and S. D'Odorico for their contribution to the improvements of the instrument. CASPEC users deserve special thanks; with their qualified and con-

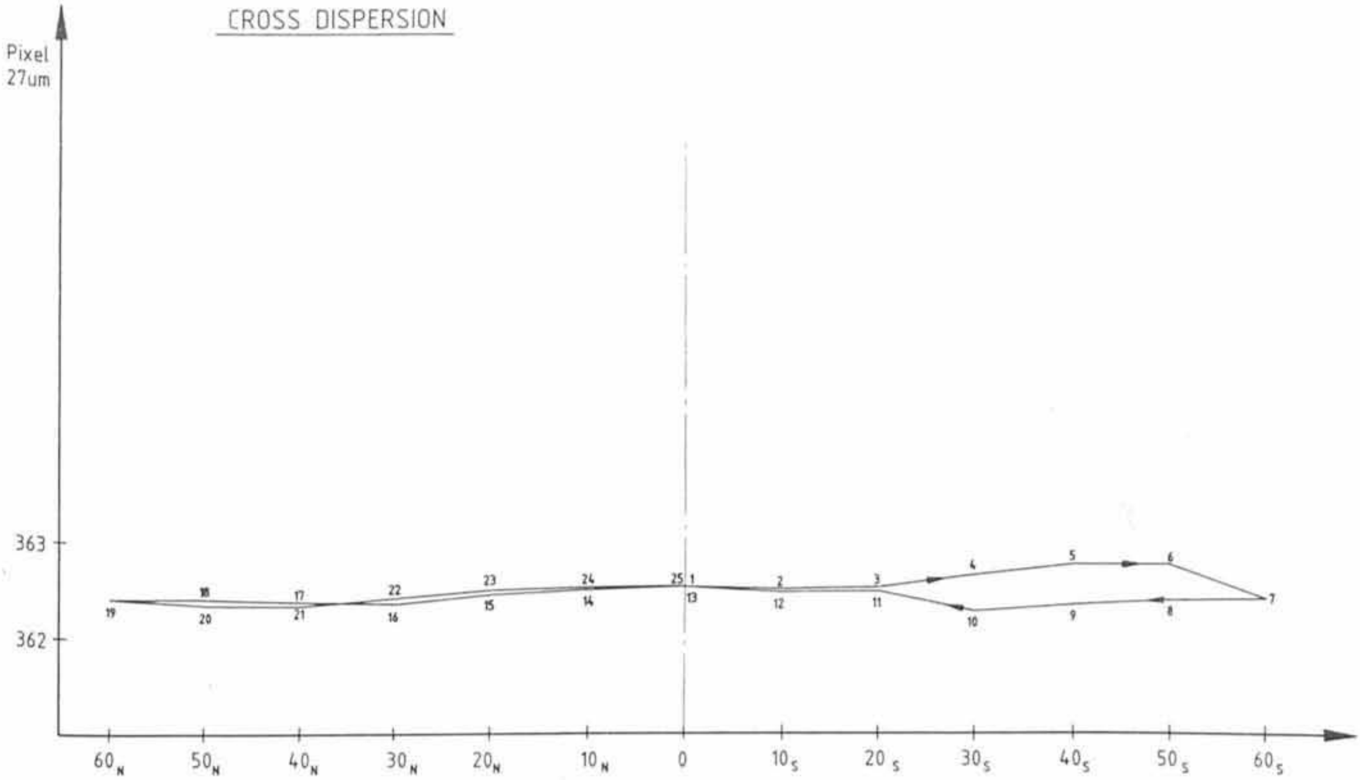

Figure 5: *An example of the tests performed to investigate CASPEC shifts: measured pixel positions of a Th-Ar line as a function of the telescope zenith distance. Slit was oriented E-W and the telescope was moved in declination.*

structive criticism they greatly contributed to these improvements.

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Optical Gyros for Astronomical Telescopes

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Pointing and tracking of telescopes requires high-precision angular encoders. Up to now classical rotary encoders have been used for this application. Their implementation in modern large telescopes with alt/azimuth mounts becomes rather difficult, because they have to be installed on the rotation axis, which has to be clear and free of any obstruction for the Nasmyth or coudé light path. In the NTT the largest monolithic encoders ever built are used, with a clear inner diameter of 50 cm. Its glass ring, which contains the division scales, has an outer diameter of 70 cm. For the VLT, with Nasmyth beams of approximately 1 m diameter, this type of encoder is not realistic any more and alternatively engraved steel scales mounted on precisely aligned cylinders will be used.

For these reasons, optical gyros have been proposed at ESO as an alternative solution, already in 1986 (1, 2). They have not to be mounted on the rotation axis because they would control the telescope (pointing and tracking) like an inertial navigation system used in airplanes, satellites, submarines, etc.

In order to assess this new approach and to demonstrate its usefulness for astronomical telescopes, ESO launched a feasibility study in April 1990. The In-

Optical Gyros

Optical gyros (J.R. Wilkinson (1987), *Prog. Quant. Electr.*, Vol. **11**, pp. 1–103) are based on the Sagnac effect (G. Sagnac (1913), *C. R. Acad. Sci*, Vol. **157**, 708). Two counterpropagating optical waves are travelling inside a ring interferometer and then combined and brought to interference. Is the interferometer not in rotation then the travel time for the two optical paths are the same and the interference pattern at the output is stationary. Is the interferometer rotating around an axis perpendicular to its plane, then one light wave sees its path shortened and the other one sees it elongated. This classical view leads to correct results for the path differences but a detailed physical description has to be based on the general theory of relativity.

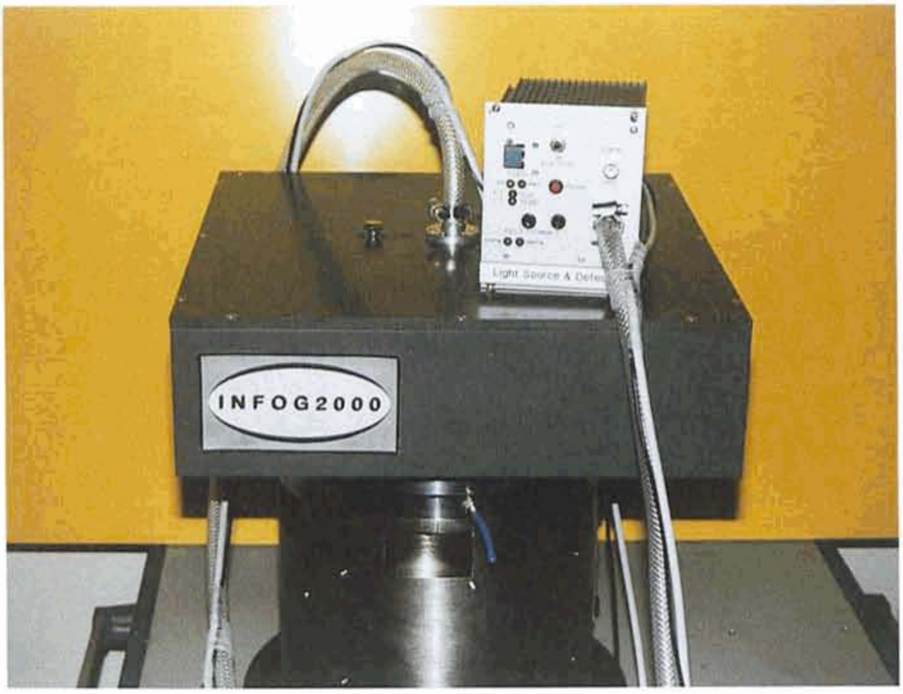

Figure 1: *View of the fibre gyro system (INFOG 2000) developed by Prof. Schröder at the FH Offenburg. The coil with 1100 m polarization maintaining fibre has 26 cm diameter and is inside the thermally stabilized and magnetically shielded square box (gyro head) mounted for test purposes on a rotation table. The small control box, which can be separated more than 15 metres from the gyro head, contains the light source (ELED at 1280 nm) and the detector and delivers the conditioned gyro output signal. (Photo: FH Offenburg).*

stitut für Physikalische Sensorik at the Fachhochschule Offenburg (FHO), Germany, started with a theoretical investigation of this concept in view of the specific requirements in astronomical telescopes and came up with a proposal for a fibre/laser gyro combination in order to cover the pointing as well as tracking phase in telescope operation.

A first prototype for the fibre gyro part has recently been completed at the FHO (see Fig. 1) which would already meet the VLT requirements for tracking with an accuracy of better than 0.1 arcsec over 30 seconds, and a resolution higher than 0.02 arcsec. Commercially available systems currently do not provide this accuracy and resolution. The construction for an improved version which will be delivered to ESO (3) and tested on the NTT next year has just started. This fibre gyro will be combined with a commercially available laser gyro covering the faster slewing and pointing operations of the telescope. A Litton LTN-90 laser gyro system has been considered for this.

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Multi-Object Spectroscopy with an Automatic Fibre Positioning System in a One-Degree Field

First Technical Run of MEFOS at the Prime Focus of the 3.6-m Telescope

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1. Introduction

Several scientific programmes require the acquisition of a large number of spectra to build up a statistically significant sample of data. Typical examples of this category are studies of galaxies in clusters or in the field and surveys of QSO candidates and peculiar stars in selected galactic regions or in nearby galaxies. In the last decade, optical fibres have been successfully used in gathering the light of different targets spread over the field of a telescope to a common spectrograph slit and thus to speed up the process of data collection.

In the first generation of instruments of this type, the fibres – typically between 40 an 100 – are manually inserted in predrilled plates mounted at the focal plane of the telescopes. The ESO facility OPTOPUS (1986, *ESO Operating Manual* No. **6**) is based on this principle and is successfully in operation at the La Silla 3.6-m telescope since 1986 as a common user instrument. Its performance has recently been upgraded with the introduction of two new fibre bundles and of a new F/6 collimator (Avila and D'Odorico, 1991, preprint). The plate drilling operation has recently been transferred to the ESO workshop at La Silla. In the second generation of fibre instruments, which came into use more recently, the positioning of the fibres in the field is done automatically at the telescope in order to skip the need of the predrilled plates and to retain realtime control of the fibre position. Systems of this type have been prototyped by Hill and Lesser at the Steward Observatory (1988, Proceedings of the 9th Santa Cruz Workshop, ed. S. C. Barden, p. 233), by Parry and Gray at the Anglo-Australian Telescope (1986, *SPIE* **627**, 118) and by Ingerson et al. at Cerro Tololo (1991, in preparation).

In 1989 ESO concluded an agreement

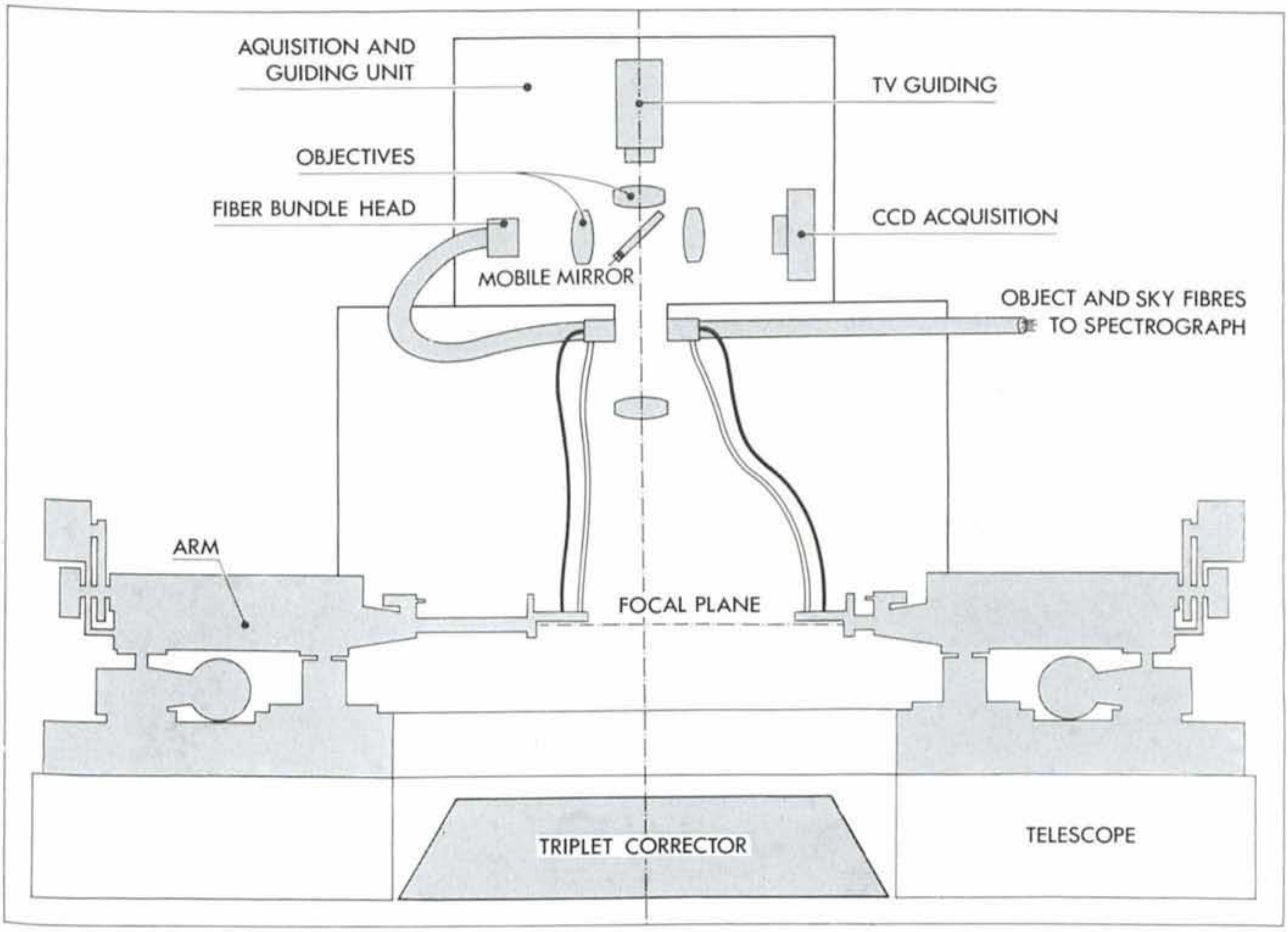


Figure 1: *General scheme of MEFOS showing its main modules and attachment at the prime focus of the ESO 3.6-m telescope.*

with the Observatoire de Paris, then led by the late Pierre Charvin, to have an automatic fibre positioning device built for the prime focus of the 3.6-m telescope. The concept of the instrument was inspired by the systems built at the Steward Observatory and at Cerro Tololo, but it includes some original features. It has the advantage of shorter setting time – the arms can move in parallel – and it gives the possibility to easily correct for atmospheric diffraction and to improve the sky subtraction by switching between object and sky fibres during the exposures. The agreement foresees that the group led by Paul Felenbok at the DAEC department in Meudon will design and build the fibre positioning and target acquisition/guiding units while ESO will deliver the fibre optics bundle and take care of the interface to the telescope and the existing grating spectrograph. The instrument schedule foresees the final installation at the telescope by the last quarter of 1992. In January 1991, a prototype version of the instrument named MEFOS (Meudon-ESO Fibre Optics Spectrograph), was tested at La Silla. This article gives an overall view of the instrument and briefly reports on the results of the first telescope test.

2. The MEFOS Project

At the ESO 3.6-m telescope prime focus, using the triplet corrector, a flat, corrected field of one degree diameter is available for faint-object spectroscopy. MEFOS is designed to pick up targets over this field. Figure 1 shows its overall structure. Four main subsystems can be identified: *the positioning arms, the fibre optics, the acquisition and guiding system* and *the spectrograph*. There are 30 positioning arms arranged in a circle at the edge of the field, each of them carrying two spectroscopic fibres and one image fibre bundle. The F/3 input aperture of the beam at the prime focus is well suited for the best performance of the fibres as far as the focal ratio degradation is concerned. No front lenses are needed at the fibre top ends. The bundle of spectroscopic fibres is guided to the Cassegrain cage where it is interfaced to a modified Boller and Chivens spectrograph. This could be substituted in the future by a dedicated bench spectrograph mounted in a stationary configuration in one of the coudé rooms of the telescope.

The output ends of the image fibre bundles are projected onto a CCD viewing camera fixed to the structure of MEFOS and used for target recognition and centring.

2.1 Positioning Arms

Figure 2 shows the 30 positioning arms – without the tips carrying the fibres – during the integration on their support flange. This flange is interfaced to the top of the prime focus triple corrector unit. It can be tilted in order to match the plane of motion of the fibres to the telescope focal plane. Figure 3 illustrates the design of one positioning arm. Each arm sweeps a triangular zone by rotation and translation. It is activated by DC motors coupled to optical encoders. The distance between the two spectroscopic fibres is 3 mm or 59 arcsec on the sky.

2.2 Optical Fibres

The two single fibres used for spectroscopy have the same projected aper-

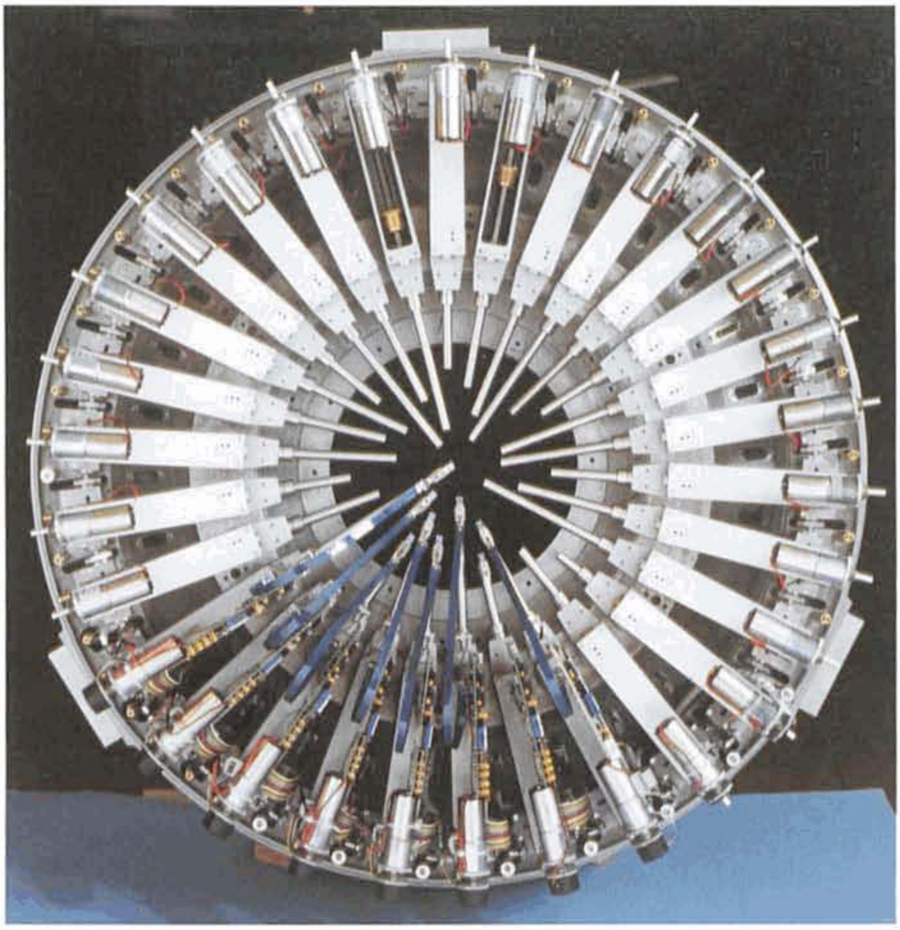


Figure 2: *MEFOS top view with all 30 positioners. 8 arms are shown with their drive cards. The fibres are not installed.*

The polished input fibre ends directly pick up the F/3.1 beams at the prime focus. The output ends, arranged on a line to form the slit of the spectrograph, feed a F/3 dioptric collimator fitted to an existing B&C spectrograph. With these apertures, the focal ratio degradation along the fibre is minimal: an average of 90% of the light is recovered by the collimator. The fibre absorption and the reflection losses at the fibre ends are not included, but they are estimated to be of the order of 10% at visual-red wavelengths. By the process of degradation of the focal ratio at the fibre output the central obscuration shadow of the Cassegrain telescope is partially filled in. For this reason, we have avoided the use of camera optics with central obscurations in the spectrograph.

The image fibre bundles have a surface of 1.9×1.9 mm, i.e. 36×36 arcsec on the sky.

2.3 Acquisition and Guiding System (AGIS)

Figure 1 shows the scheme of the unit which is mounted on a plate above the arms. All the output ends of the image fibre bundles are packed together and projected onto a CCD by two photo-objectives, giving a scale of 50.8 μm/arcsec. Before the beginning of an observation each arm moves the image fibre bundle to the calculated position of

ture on the sky: 2.6 arcsec (135 μm). The fibre length needed to link MEFOS to the spectrograph located in the Cassegrain cage is 21 m. For the first run at La Silla we used Polymicro FBP fibres. This type of fibre shows a flat transmission between 500 and 1200 nm, as illustrated by the continuous line in Figure 4. To increase the efficiency in the blue wavelength region (350–450 nm) we will use in the future the so-called "wet" fibres. As shown by the dashed line in Figure 4, this kind of fibre is much more transparent in the blue but exhibits water absorption bands in the near-infrared region.

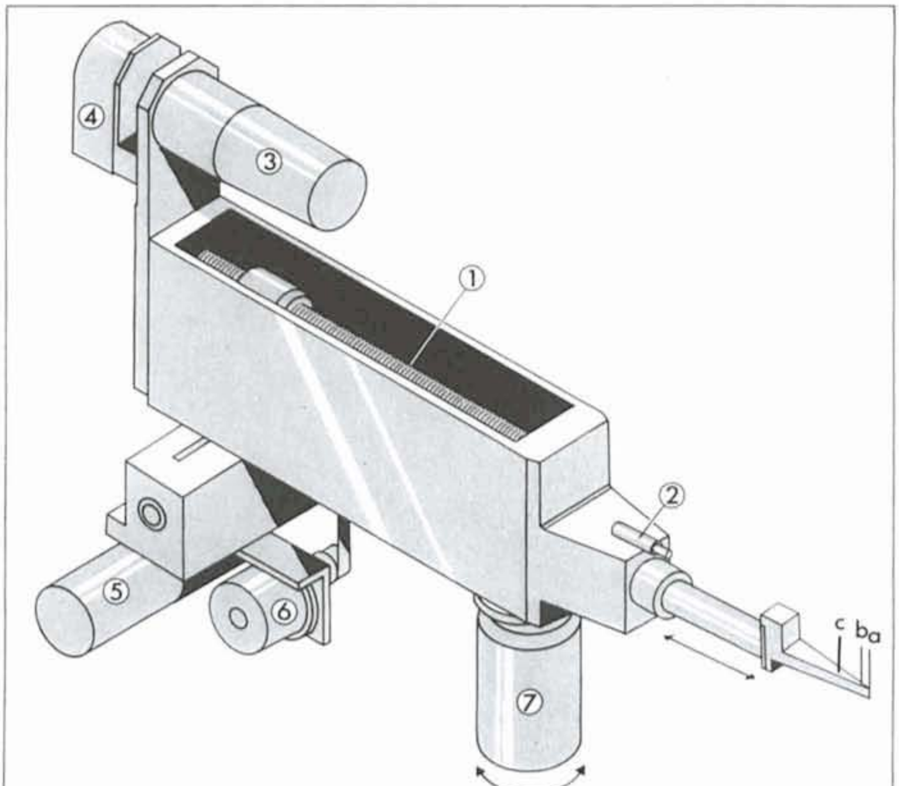


Figure 3: *Detailed view of one positioner. A high-precision screw (1) with a 0.5-mm pitch is used for the radial movement of the arm. A switch (2) provides the definition of the zero reference point with a precision of 1 μm. A DC motor (3) is coupled to an optical encoder (4) for the radial movement, (5) and (6) are the motor and the encoder for the rotation of the arm around the pivot (7). The spectroscopic fibres are labelled by (a) and (b), the image fibre bundle by (c).*

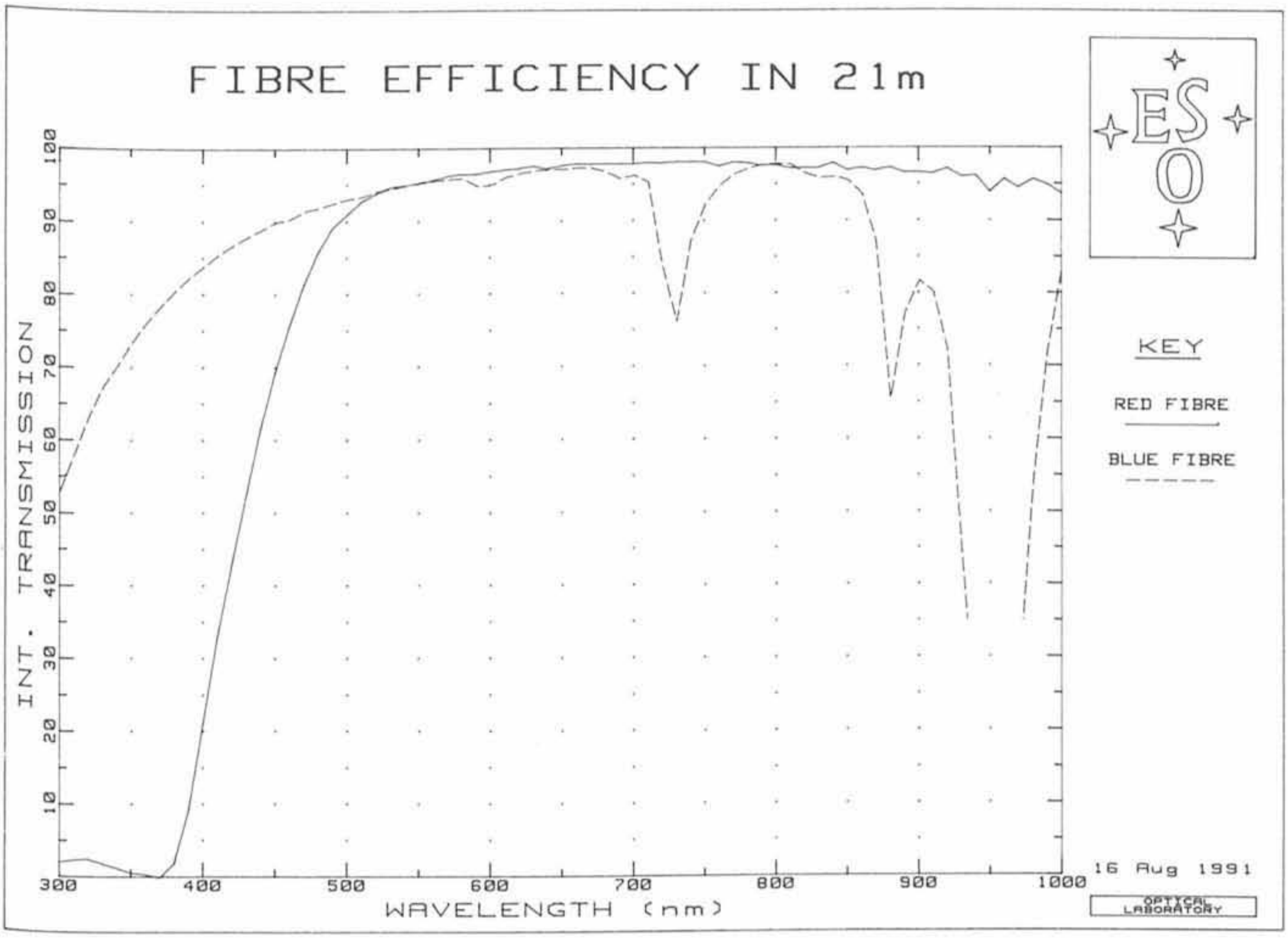


Figure 4: *Internal transmission of 21-m fibres in the 300- to 1000-nm wavelength range. Continuous curve: fibre optimized for the visible-red wavelengths. Dashed curve: fibre optimized for the blue spectral region.*

its assigned target. A short CCD integration then gives subimages of all 30 targets. These are processed to compute the exact object positions with respect to the single spectroscopic fibres on the corresponding arms. Finally the arms are moved by the computed offsets and the integration of the spectra can be started.

The acquisition camera uses a Thomson CCD with 1024×1024 pixels of 19 μm, cooled with a two-stage Peltier device to about −60°C. Lower temperatures are not needed because the exposure time will never exceed a few minutes and the read-out noise is small compared to the sky photon noise. A 12-bit A/D converter is used in the commercial CCD control camera leading to a sufficient dynamical range and to a fast read-out.

As shown in Figure 1, the acquisition system is placed in such a way that a separate TV camera can monitor the centre of the field by means of a third photo-objective. A movable 45° mirror may be inserted to project the image fibres on this TV camera. In this position, the automatic guiding of the telescope

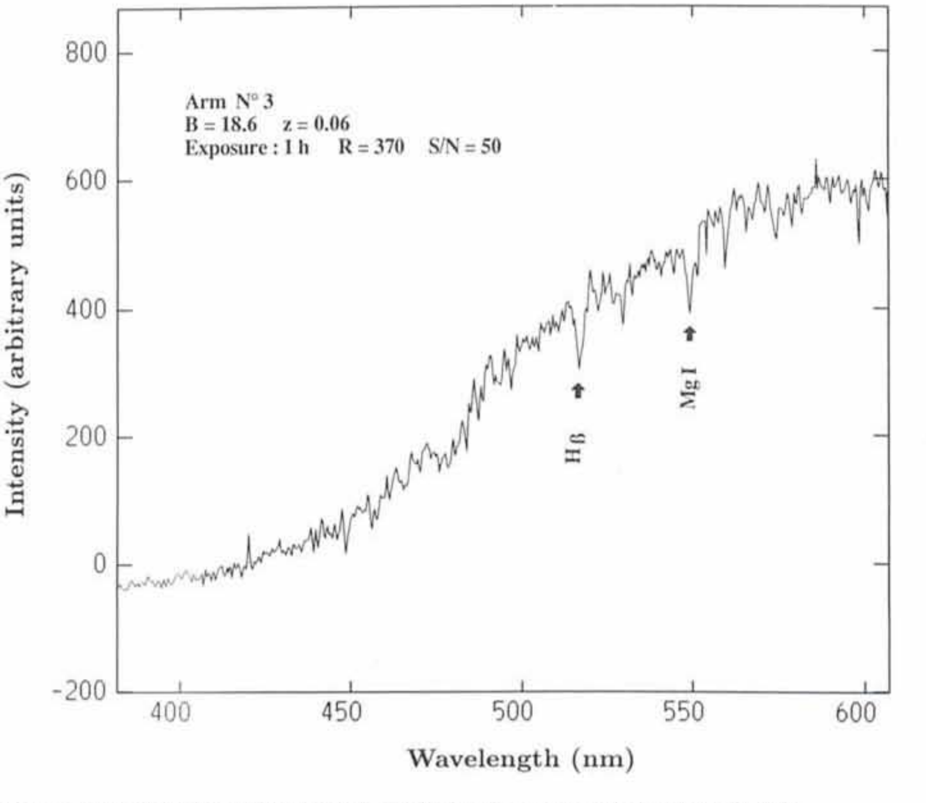


Figure 5: *Example of a sky subtracted spectrum of a galaxy, obtained with MEFOS.*

can be achieved with one image fibre pointing to a conveniently bright star in the field. If such a star cannot be seen on any of the image fibre bundles, one of the arms must be moved to find it.

2.4 Control of the Instrument

An Olivetti M300 PC/AT is used for the general control of the positioners and the Acquisition and Guiding module. The arms are driven by a central master card located in the PC. This card is connected through two optical fibers to slave cards located on each positioner. Both cards, master and slaves, are based on 8 bit 80451 and 80535 microprocessors, respectively.

The coordinates of the arm positions are stored in the master card. The latter questions and sends commands to all the arms; once well received and acknowledged, these commands are executed by the arms. The arms move therefore simultaneously and the maximum time to set up a field configuration from the "parking" position is less than 5 minutes with a repeatability of 10 μm (0.19 arcsec). The master microcontroller continuously scans the whole system. By questioning the master card, the user can observe in "real time" the dynamic state of the system.

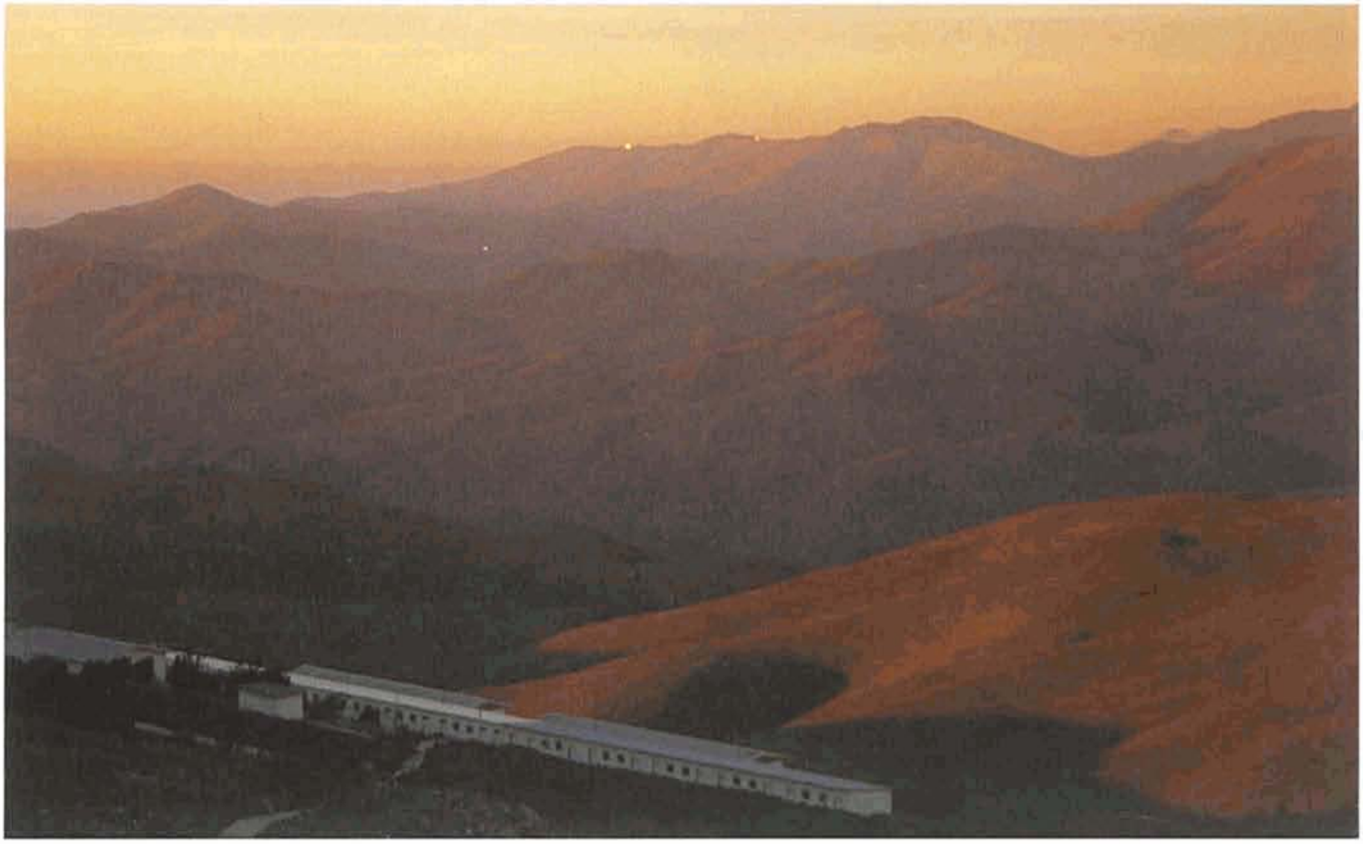
Communications between the master and the slaves are done in serial at a data rate of 375 Kbaud. The two optical fibres (transmit and receive) have a length of 75 m and are provided with an error-detection procedure.

The software that drives the whole instrument is written in C. The user provides files stored on floppy disks with the object coordinates α and δ in the fields of interest. These coordinates are converted in r, θ coordinates in the telescope focal plane. The object-to-arm assignment is made by software using the Hungarian algorithm for the best match and to avoid collisions. The coordinates stored in the master card are then distributed to the assigned arms, which first move the image fibres to the objects. The programme eventually takes care of moving the arms to set the spectroscopic fibres on the targets as explained in section 2.3.

2.5 Spectrograph

The Boller & Chivens spectrograph has been adapted to the use with MEFOS. The standard F/8 parabolic mirror used as collimator and the Schmidt camera have been replaced by two fully dioptric elements, an F/3 collimator and an F/2 camera, respectively. With this new configuration the fibre-spectrograph matching is optimal. As was mentioned above, the light losses at the central obscuration of the camera are avoided and the focal ratio degradation at F/3 is minimal. During the first test observation in January 1991, the spectrograph detector was a Tektronix CCD with 512×512 pixels of 27 μm. The fibre output ends project a diameter of 86 μm or about 3 pixels on the detector. The usual complement of gratings and corresponding dispersions of the B & C spectrograph in the OPTOPUS configuration is available to the observers.

A Distant View of . . . Las Campanas



With reference to the article by W.C. Keel in an earlier issue of the *Messenger* (**55**, p. 29) in which a distant view of La Silla was reproduced, I should like to inform the readers that spectacular views of an observatory are also available to visiting astronomers at La Silla itself.

This photo was taken during my last visit to La Silla on May 2, 1991, around 18.00 from the 1-m telescope. From my experience as a long-time La Silla resident astronomer, the most favourable epochs of the year are are around one and a half months before and after the June solstice.

TH. LE BERTRE (DEMIRM, Observatoire de Paris, France)

3. First Technical Run at the 3.6-m Telescope

The first test run of MEFOS at La Silla took place from January 30 to February 7, 1991. The final instrument structure was used but with nine positioning arms only. The goal of the observing run was to check the telescope interfaces and to practise all instrument mounting and adjustment procedures. The fibre output slit could be mounted either at the spectrograph collimator or at a photomultiplier to verify the accuracy of the fibre centring. The whole system (including the read-out of the photomultiplier) was controlled by the instrument PC in the Control Room.

The spectral calibrations and flat-fields were performed using the Optopus flange mounted, as usual, on the Cassegrain adapter. The lamps sent the beams directly to the prime focus through the central hole of the main mirror. They were controlled together with the spectrograph CCD by the OPTOPUS software package running on the HP 1000 telescope computer.

Apart from minor difficulties in the mechanical installation and in the control software, the main problems were encountered in the object acquisition: at the beginning the arms were not able to reach the correct positions. This was traced down to a slightly erroneous value of the scale we were using. After this correction, the final position of the arms was still not fully satisfactory because the programme did not yet include the field distortion. Nevertheless, once the objects were brought inside the image fibres and analysed with the acquisition programme, the arms could send the spectral fibres to the objects with relatively good accuracy: better than 0.4 arcsec. Two factors contributed to this uncertainty: the spherical aberration produced by the non-perfect alignment of the triplet corrector, and small drifts in the tracking of the telescope during the acquisition exposure time. In the laboratory the procedure of target acquisition and displacement of the arms to put the spectral fibre in front of the object yields an accuracy of better than 10 μm or 0.17".

In the last three nights of the run, a number of scientific exposures were obtained. The most important exposure was on a field of galaxies with magnitudes between 17.5 and 18.6. This field had been observed before with OPTOPUS by C. Balkowsky and R. Kraan-Korteweg. The field acquisition exposure time of 5 min and the spectral exposure time of 1 hour proved to be sufficient for the purpose. The spectrum displayed in Figure 5 is from a galaxy of $m_B = 18.6$, $z = 0.06$ and reaches a signal-to-noise ratio of 50. An actual measurement of the relative efficiency of MEFOS and OPTOPUS is almost impossible because of the strong dependence on seeing. A computation which takes into account telescope, fibre and spectrograph effects indicates that MEFOS should be approximately 25% more efficient than OPTOPUS.

Acknowledgements

The design and construction of this instrument was done under the responsibility of André Collin and the mechanical workshop of the CNRS at Bellevue. We are grateful to Daniel Hofstadt for his continuous support of the project, to all colleagues who helped us during the test in Chile – in particular A. Gilliotte, M. Maugis and O. Lavin – and to P. Focardi for her help in the data reduction.

News on ESO Instrumentation

S. D'ODORICO, ESO

1. EMMI

EMMI, the ESO Multi-Mode Instrument, is in regular operation at the Nasmyth B focus of the NTT since November 1990 (see *The Messenger* **61**, p. 51). In March and April of 1991 part of the EMMI team (H. Dekker as project coordinator and optical engineer, J.L. Lizon for opto-mechanical integration and testing, A. Longinotti and G. Raffi for the control software, R. Reiss for the CCD and the author for the astronomical tests) was again on the mountain for a number of upgrades on the instrument. These are shortly summarized below.

1.1 Multi-Object Spectroscopy

The operation and the first results of the MOS mode of EMMI have been described in the *Messenger* No. **63**. Further work was needed to refine the object selection software, for slight modifications of the hardware and to prepare a user interface. The work is now completed and the mode is in operation. Figure 1 shows one MOS observing sequence. Table 1 lists the main parameters and compares them with the equivalent facility in EFOSC1 at the 3.6-m.

1.2 Medium-Dispersion Spectroscopy with the Dichroic

The DIMD mode is now also in operation. In this configuration the slit is fed by a wide-band mirror instead of the blue- or red-optimized mirrors and the blue and red beamsplitter prism below the slit is replaced by a dichroic prism. All types of coatings represent state-of-the-art coating technology. The absolute efficiencies as measured in the ESO optical laboratory are shown in Figure 2. The EMMI control software fully supports the DIMD mode and allows parallel exposures (but sequential read-out) of the two CCDs.

TABLE 1: *MOS in EMMI and (for comparison) EFOSC1*

	EMMI	EFOSC1
Wavelength range (A)	4200–10000	3600–10000
Field (arcmin)	10×10	3.6×5.8
Punch field (arcmin)	5×8	3.6×~4
Aperture shape	slit	circ. hole
Hole size (arcsec)	1.3×8.6 1.9×8.6*	2.1 3.6
No. objects per field (typical)	10–30	5–15
Punching machine	on line (on EMMI)	off line (control room)

* Available October 1991.

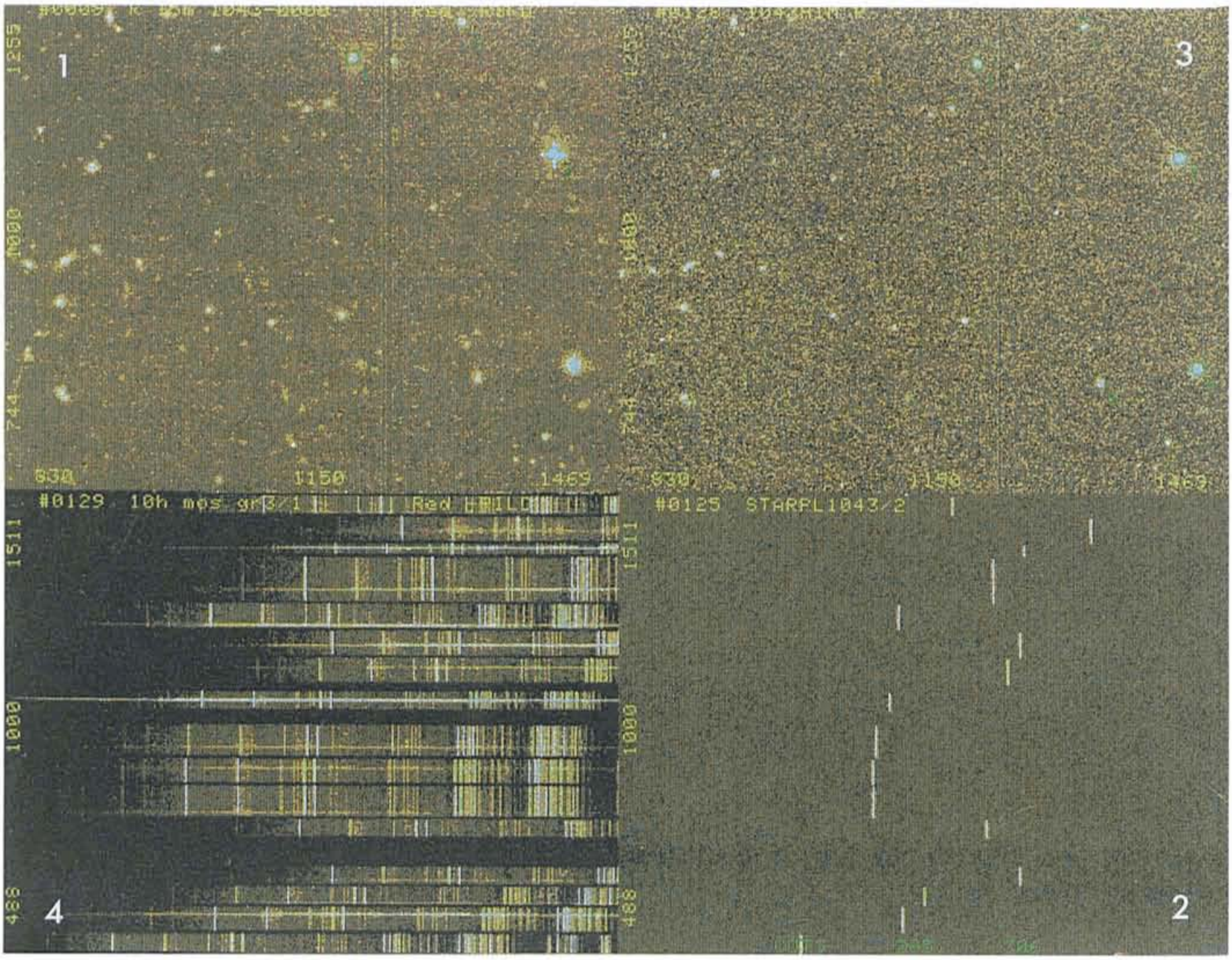


Figure 1: *These four images taken by H. Dekker, B. Peterson and the author in March 1991 illustrate the steps in obtaining a MOS exposure in the red arm of EMMI. Image 1 is a 15-minute R exposure of an empty field at high galactic latitude (see a deep image of the same field in the front page of the* Messenger *No.* ***64****). The brightest galaxies have visual magnitudes of 20–22. Object selection for later multi-slit spectroscopy is carried out with an interactive programme running at present in the IHAP environment. At the end a punching file is produced. This operation may take between 20 and 60 minutes depending on the number of objects and the complexity of the field. The aperture plates (up to 4) are mounted in a wheel in the instrument and punched there by a special device. A quick calibration exposure (image 2) is used to check the quality of the slits. The whole operation can take place in the afternoon preceding the spectroscopic observations. At the beginning of the night, a short image of the same field is obtained (image 3). The alignment correction is usually very small due to the high pointing accuracy of the telescope. The spectroscopic exposure is finally obtained: image 4 shows a 75-minute exposure on galaxies in the magnitude range 20.5-22.*

1.3 A Ford 2048^2 CCD Installed in the Red Arm

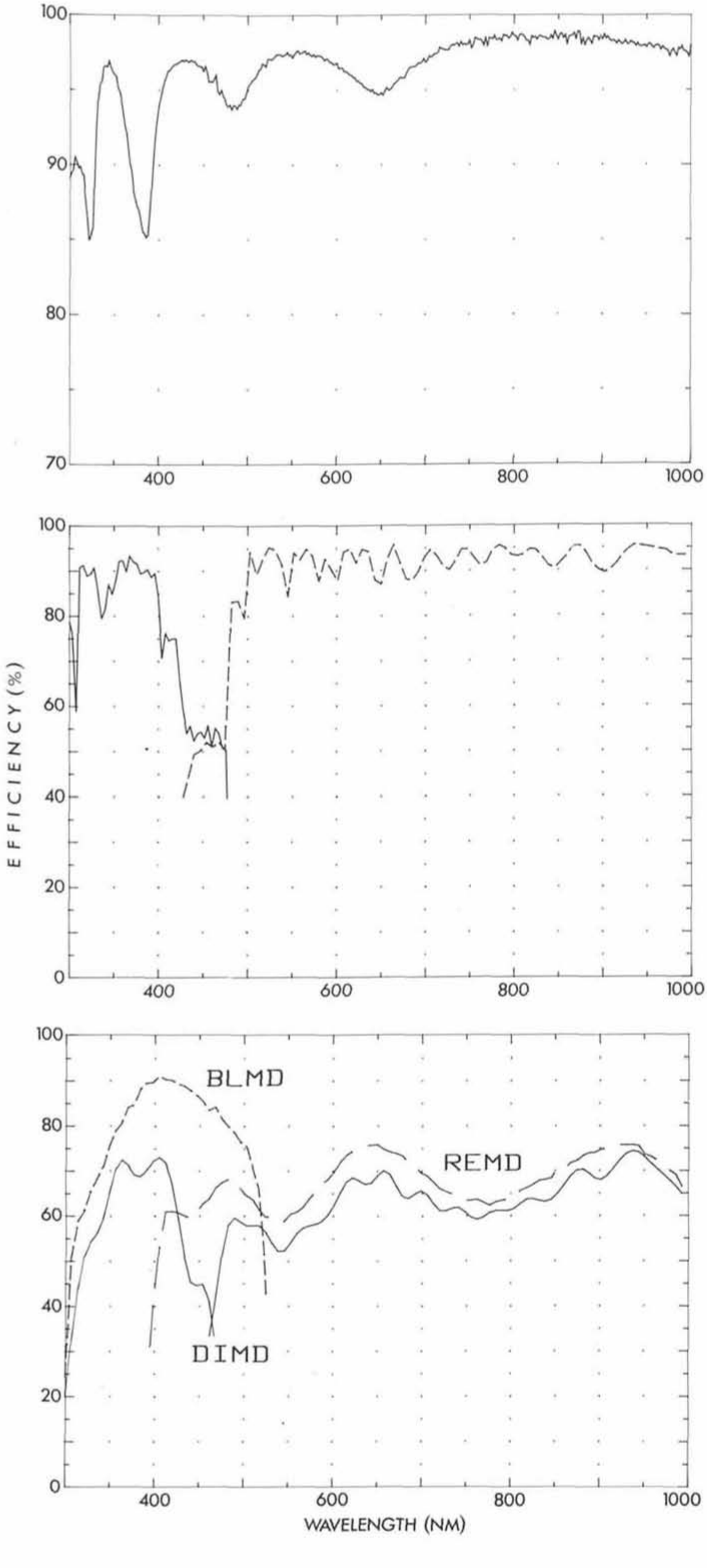
In the first six months of observations, the red arm of EMMI operated with a coated 1024^2 TH CCD as a detector. A number of complaints were received because of the compressed scale (0.44 arcsec/pixel), of the field limitation and of the heavy fringing at red wavelengths due to the coating. In April a 2048^2 Ford CCD was installed: this now gives the full field of the instrument (10×10 arcmin) with a better scale (0.35 arcsec/pix). The cosmetic is excellent and the CCD is uncoated. The efficiency is lower than for the coated Thomson CCD below 450 nm only, a region where the red arm is not really designed to operate. Still there are applications where the lower r.o.n. of the Thomson ($4e^-$ instead of 7 of the Ford) is an asset. While the discussion between the two detector options goes on, we plan to install a new CCD next year (see below).

TABLE 2.

THE SUSI PROJECT TEAM	
S. Balon	Procurement of mechanics. Integration and testing. Installation
J. Brynnel and W. Nees	Electronics
R. Buettinghaus	Integration and mechanical manufacturing
S. Deiries and T. Ducros	CCD preparation and testing
G. Hess	CAD design and drafting. Documentation
H. Kotzlowski	Instrument conceptual and mechanical design (Project Coordinator)
J.L. Lizon	Flexure testing
S. Longinotti	Control software
R. Reiss	CCD installation and optimization. CCD controller
G. Rupprecht	Procurement of optical components

1.4 Upgraded Version of the User Interface

EMMI is a complex instrument which offers on-line two large-size CCD detec-



tors and very different modes of observations, from echelle spectroscopy to multi-object spectroscopy. Given this background it is not surprising that the occasional user needs time to learn how to deal in the most efficient way with the instruments and its control software. It is the (perhaps biased) opinion of the author that instruments like EMMI should be ideally operated in a service mode to exploit in the most efficient way their capabilities, but it is very difficult, besides being expensive, to find and train the right operators for this type of work. In the meantime, we have to rely on the good will and the unlimited resources of the visiting astronomers. The excellent scientific results obtained at the NTT by many visitors prove that the learning process can be very fast and effective.

In these first 9 months of operation the control software, initially not bug-free, has been consolidated and a new, more friendly version of the user interface was installed in April. In November 1991, a further upgraded version will be installed, again with the goal to speed up some operations and to make the system simpler to use. Thanks to the work of the La Silla software group, a work-station has also been added to the system for data acquisition and to operate MIDAS at the telescope. This is of considerable help because the HP computer-based data-analysis system IHAP cannot handle large-size (2048^2) CCD images.

1.5 Planned Improvements of EMMI

Two detector changes are foreseen to further improve the performance of the instrument. In November of this year it is planned to install a thinned 1024^2 TK CCD in the blue arm to increase the efficiency and to increase the field. In the middle of 1992 it is – tentatively – planned to install a 2048^2 TK device in the red arm to increase the efficiency in the 400–500-nm range.

2. SUSI

With the installation of EMMI at the Nasmyth B focus of the NTT in November 1990, the possibilities of high angular resolution imaging at the NTT had become limited. With the installed optical cameras and CCD detectors, the EMMI pixel size is 0.29 arcsec in the

Figure 2: *Absolute efficiency of the EMMI wide-band coated mirror (top) of the dichroic (centre) and of the medium dispersion modes of EMMI (bottom). The blue MD channel (BLMD), the red MD channel (REMD) and the dichroic MD (DIMD) are identified.*

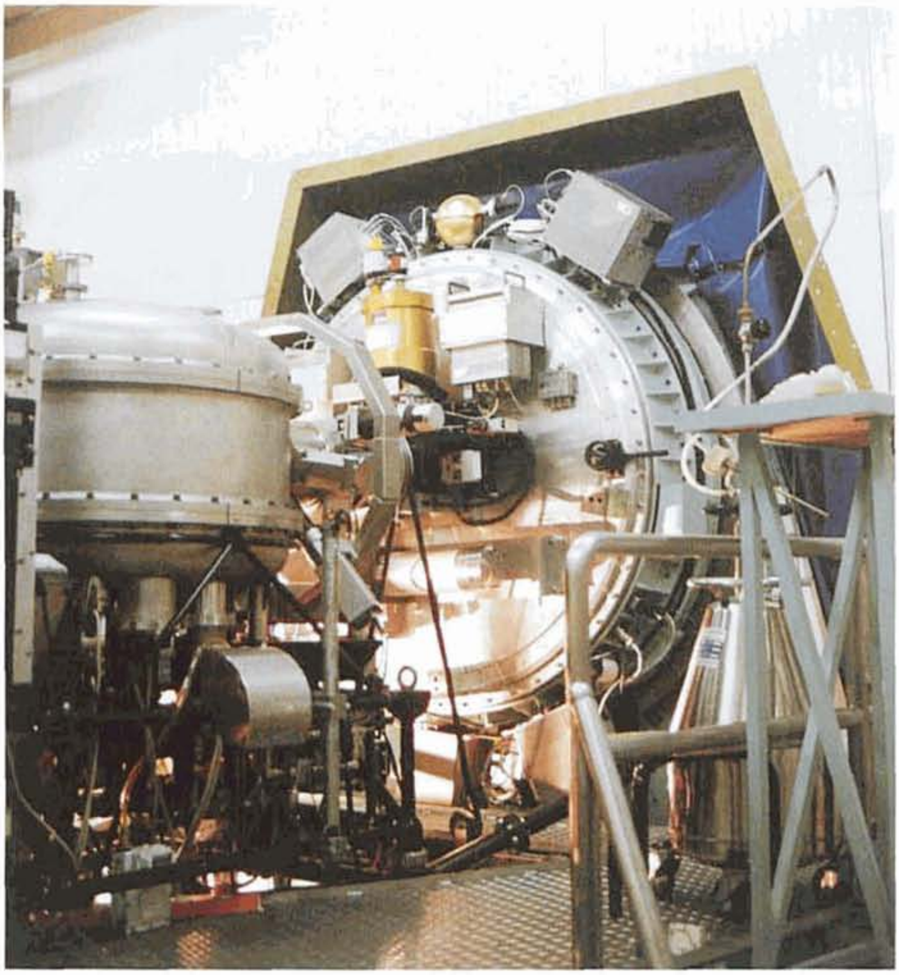


Figure 3: *SUSI installed at the Nasmyth A focus of the telescope. The CCD dewar and the control electronics are visible at the top of the adapter, the access platform and IRSPEC in the foreground.*

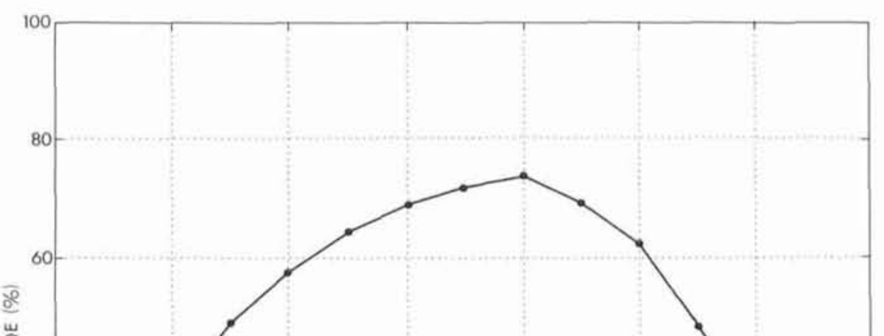


Figure 4: *Quantum-Efficiency Curve of the thinned 1024^2 pixel TK CCD (ESO No. 23) now mounted on the SUSI direct-imaging camera.*

blue arm with the 1024^2, 19-μm pixel Thomson CCD and 0.35 arcsec in the red arm with the 2048^2, 15-μm pixel Ford CCD. With these scales the CCDs cover the total corrected field of the instrument. It is an optimal compromise between the requirements of the different modes of observations of the instrument, but the stellar images are not sampled in an optimal way when the seeing is better than 0.7 arcsec approximately. The experience of the first year of operation of the NTT has shown that this happens for a relevant fraction of the observing time, and therefore unique opportunities for imaging at high angular resolution could be lost. To fill the gap, ESO developed in a 6-month crash programme a dedicated imaging facility named SUSI, the SUperb Seeing Imager to be mounted on the adapter at the Nasmyth A focus and to be used as a standby mode of EMMI for observations in unique seeing conditions (see also the article by J. Breysacher and M. Tarenghi on the introduction of flexible scheduling at the NTT in the *Messenger* No. **63**, p. 6).

In April 1991, SUSI was installed at the NTT and *immediately* offered to the visiting astronomers whose programmes call for high angular resolution. The user interface will be finalized in November 1991. The change from EMMI to SUSI (Nasmyth A to Nasmyth B) can take as little as 10 minutes. Figure 3 shows the instrument at the telescope. Because of the narrow space between the adapter/rotator and the derotator of the stationary IRSPEC, SUSI has a very simple and compact structure. At the centre of the field, a three-position mirror unit takes care of directing the light to an optical CCD or to a "visiting" detector (at this time a mechanical dummy is mounted) or to let it finally pass through to IRSPEC. The CCD dedicated mirror used at present is aluminized. In November, a wide-band, high-efficiency coated mirror with the efficiency shown in Figure 2 will be installed. A filter wheel with 8 positions is placed in front of the CCD shutter in the F/11 converging beam of the NTT. The internal diameter of the single filter cell to be fitted in the wheel is 60 mm. The CCD detector presently used is a thinned TK 1024^2, 24-μm CCD. This leads to a pixel size of 0.13 arcsec and a field of 2.2×2.2 arcminutes. The quantum-efficiency curve as measured by ESO is given in Figure 4. The design of the mirror unit and of several other parts profited from the experience on the EMMI functions. Still, to have the instrument designed, built by external firms, integrated and tested in Garching and later in Chile within little more than 6 months was a major achievement

Figure 5: *(a) A 2-minute R exposure on the irregular galaxy NGC 3109 at the red arm of EMMI. A windowed format of 1700 × 1000 pixels (10 × 5.8 arcmin) in the 2048^2 Ford CCD was used. The FWHM of the stellar images is 1.1 arcsec. (b) A 3-minute exposure of a section of the same galaxy taken with SUSI through a Gunn i filter. The FWHM of the stellar images is 0.55 arcsec. The two white crosses near the faint spiral galaxy at the centre of the image are separated by 2 arcsec. The brightest star is identified by the two white arrows in the corresponding EMMI image.*

Figure 6: *The centre of the Terzan 7 cluster from a 900-second B exposure with SUSI (courtesy of Roberto Buonanno, Osservatorio Astronomico di Roma). The FWHM of the stellar images is on average 0.46 arcsec.*

for which the SUSI project team (see Table 2) is to be congratulated. That the effort paid off can be seen from the two examples of astronomical observations (Figs. 5b and 6).

MIDAS Memo

ESO Image Processing Group

1. Application Developments

Besides on-going developments of new packages and improvements of existing ones, many small changes were made in the MIDAS system to remove bugs or to increase functionality and/or user friendliness. The most important ones are given below.

In the Echelle package two new methods for order definition and ripple correction have been added. Of course, the old methods are still available.

Two new commands have been implemented to correct bad rows and columns in CCD images. The method is based on a poster paper presented by G. Pojmanski at the 3rd ESO/ST-ECF Data Analysis Workshop.

The FILTER commands have been modified to take care of the frame boundaries in the filtering. In addition, the FILTER/MEDIAN command has been revised to increase its speed.

Several commands have been added to improve the usage of catalogues in

MIDAS. For example, one can now sort and search in catalogues. Also, the usage of ASCII file catalogues is now possible.

Finally, the DELETE/GRAPHICS and DELETE/DISPLAY commands can now delete individual graphic and display windows.

2. Configuration Control

Soon after the 91MAY was frozen for release, MIDAS software at ESO Headquarters was put under the Source Code Control System (SCCS). The MIDAS Group has decided to take this step mainly for three reasons:

- to improve the coordination of software development, in particular for the core and application parts of the system;
- to maintain records of changes in the system during the release cycle;
- to be able to regenerate old versions of MIDAS from the running system using the tools the SCCS system provides.

At ESO, the SCCS control has been implemented for two of the three running MIDAS versions: i.e. the development system (test), and the internal release (new). Starting with the 91NOV release, also this version (that is sent to the user community) will be controlled by SCCS. The SCCS system allows control write access to the source files, and monitor changes made to those files. Under SCCS, only one user can update a file at the time, and records of all changes are stored in a history file. All source code as well as e.g. documentation and help files are affected by the SCCS control.

With the implementation of the control system, day-to-day development of the ESO-MIDAS software can be controlled better and will guarantee a further increase in the stability of the MIDAS software.

First Announcement of the

4th ESO/ST-ECF Data Analysis Workshop

ESO, Karl-Schwarzschild-Straße 2
D-W 8046 Garching, Germany

May 13–15, 1992

The aim of the Workshop is to provide a forum for discussions of astronomical software techniques and algorithms. It is held annually during the spring (April/May) and centres on a different astronomical area each time. Due to available space, participation will be limited to 80 people. Last year it was necessary to reject some people and we therefore recommend that you register well before the deadline (Feb. 28, 1992) either through mail or E-mail.

The topic for the 1992 Data Analysis Workshop is the analysis of spectral data. The scientific section of the meeting will consist of three sessions each starting with a main talk after which papers of approximately 10 minutes duration can be presented. The last day is reserved for general user meetings for MIDAS. The tentative agenda is:

Analysis of Spectral Data

May 13:	14.00–18.00:	Optical and UV spectra
May 14:	09.00–12.30:	IR spectra
	14.00–17.00:	Multi-Object spectra
	17.00–18.00:	European FITS Committee
May 15:	09.00–12.30:	MIDAS users meeting
	14.00–15.00:	European FITS Committee

We especially welcome contributions on algorithms and techniques for identification, decomposition and profile analysis of lines, and calibration of spectra observed with two dimensional detectors. We encourage people to present their work in these areas even if it is only ideas. After each introductory talk, we will have a more informal discussion where such contributions can be made. We also plan to have a poster session where people can present short contributions. Proceedings of the scientific sessions will be published.

The scientific organizing committee includes: P. Grosbøl (Chairman), D. Baade, P. Benvenuti, S. D'Odorico, M. Rosa, J. Wampler

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3. MIDAS at the IAU General Assembly

At the XXI[st] General Assembly of the International Astronomical Union (IAU), held in Buenos Aires from July 23 to August 1, ESO was represented with a stand at the exhibition room in the Conference Centre. The main part of the exhibition was dedicated to the Very Large Telescope (VLT), now under construction in Europe and Chile. In collaboration with the ESO Information Service, the MIDAS Group used the GA event to present the MIDAS project to the astronomical community. Demonstrations of MIDAS, using a SONY News lap-top computer were scheduled at regular intervals, and a documentation set was displayed. Many visitors of the exhibition showed their interest in MIDAS and signed up to receive further information.

4. ESO-MIDAS User Agreement

During the distribution of the 91MAY release of MIDAS, some problems identifying the various requests were encountered. To avoid delays in the distribution of future releases, we kindly ask you to quote your ESO-MIDAS User Agreement number on all correspondence regarding MIDAS distribution and documentation. If you are not sure about your user agreement number, please contact Resy de Ruijscher at ESO-IPG.

5. Central Computer Facilities at ESO

As announced in the previous Messenger (No. 64, June 1991), the central computers at ESO Headquarters, two VAX 8600 systems running the VAX/VMS operating system, will be replaced. After extensive benchmarking and negotiations with several candidate vendors, ESO has purchased two Solbourne 5E/802i machines, 40 MHz SPARC technology, running the UNIX operating system. The machines were purchased from Kontron, Eching near Munich.

In the course of September the machines will be made operational, whereas at the same time the maintenance of both VAXes will be minimized. It is anticipated that the VAXes will be disconnected in the month of November. Visitors who intend to use ESO's central computing facilities for data reduction and analysis are advised to contact the Visiting Astronomers Section or the Image Processing Group of ESO.

6. MIDAS Hot-Line Service

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

- EARN: MIDAS@DGAESO51.bitnet
- SPAN: ESO::MIDAS
- Eunet: midas@eso.uucp
- Internet: midas@eso.org
- FAX.: +49-89-3202362, attn.: MIDAS HOT-LINE
- Tlx.: 528 282 22 eso d, attn.: MIDAS HOT-LINE
- Tel.: +49-89-32006-456

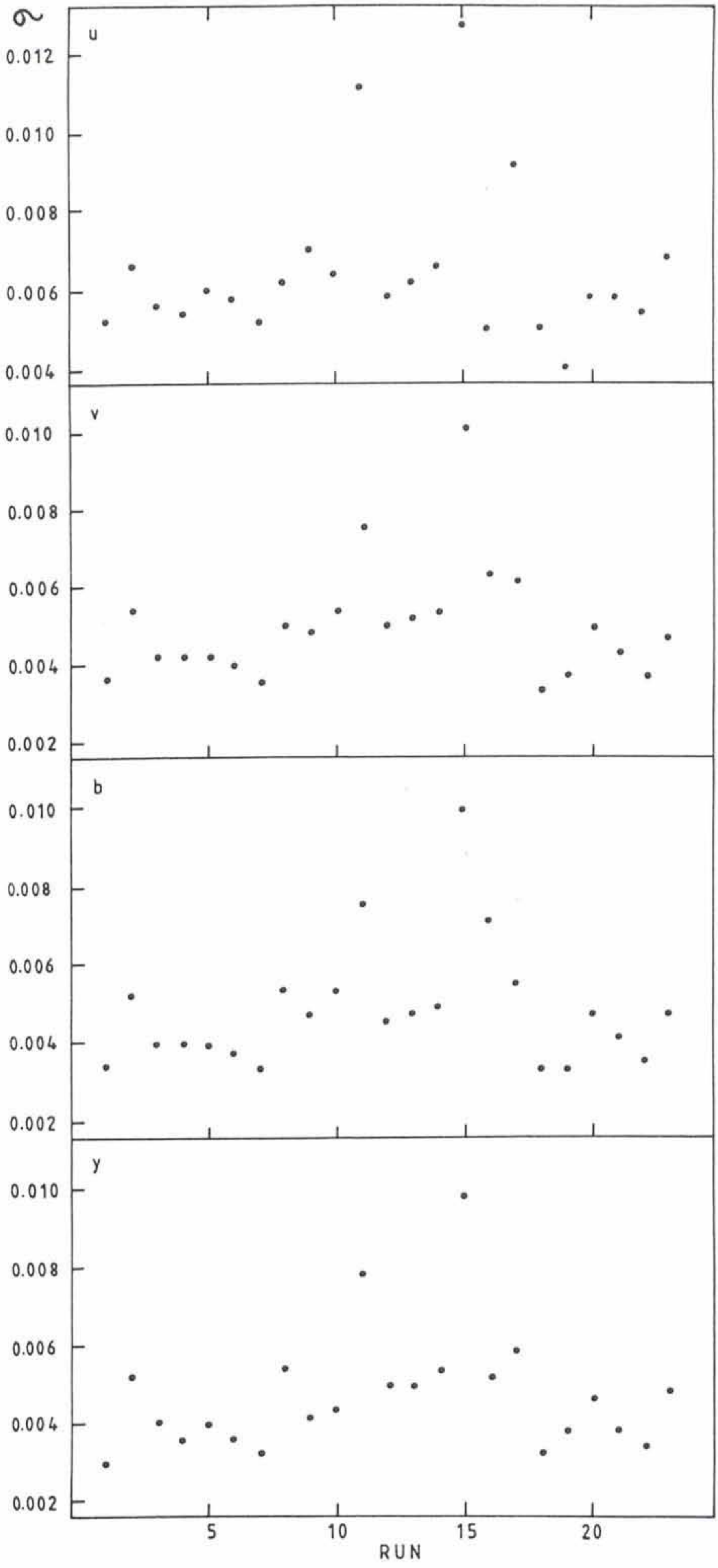
Users are also invited to send us any suggestions or comments. Although we do provide a telephone service we ask users to use it in urgent cases only. To make it easier for us to process the requests properly we ask you, when possible, to submit requests in written form either through electronic networks,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

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

News About Automatic Photometry

With reference to the earlier article in this journal (Sterken and Manfroid, *The Messenger* **63**, p. 80, March 1991) about automatic photometry at La Silla, it now appears that, after a technical intervention in 1990, the r.m.s. deviations measured at the Danish 50-cm telescope (SAT) have returned to the level measured before the automation. The figure shows the standard deviations in u, v, b and y (0.001 mag) of the mean magnitude differences between standard stars (pairs for which more than 6 observations in each observing run were available). Observing runs 1 to 8 (August 1986) are in the manual mode and the later observations are in the automatic mode. Note the low level of the latest runs.

C. STERKEN, Astrophysical Institute, University of Brussels (VUB), Belgium



Aluminium Mirror Technology at ESO: Positive Results Obtained with 1.8-m Test Mirrors

P. DIERICKX and F. ZIGMANN, ESO

The aluminium alternative for the manufacturing of astronomical mirror blanks developed initially around the NTT project. A series of tests on 500-mm samples [1] led to the conclusion that a 4-metre-class aluminium mirror was feasible [2], with a similar level of quality as a glass mirror. This option was seriously considered for the NTT active primary mirror but finally canceled because of schedule problems. In addition to being much less expensive than glass, aluminium also presents advantages [3] such as reduced fragility, easy machining, possible repair and excellent thermal conductivity. The latter almost eliminates the risk of thermal gradients (in normal operation) and would improve the efficiency of thermal control (mirror seeing). The main problem is that few data on long-term stability exist. Since 1968, Merate Observatory runs a 1.4-m telescope with an aluminium primary. Measurements carried out by ESO in 1982 showed a total aberration of less than 1 fringe, well within the spatial frequency range of an active support.

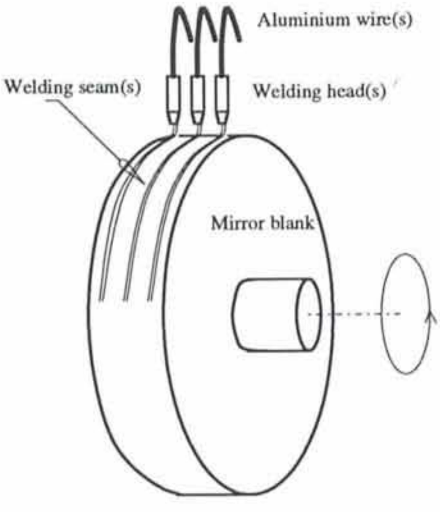


Figure 1: *Build-up welding (mirror vertical).*

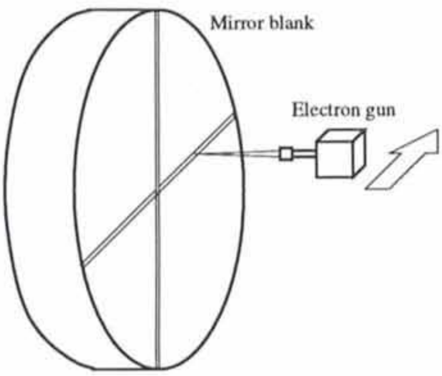


Figure 2: *Electron-beam welding (mirror vertical).*

Development continued within the framework of the VLT programme [4]. Since the technology selected for the NTT (casting) does not seem extrapolable above four metres, different manufacturing processes had to be investigated. Initial tests on 500-mm samples led to the selection of two promising techniques: build-up (BU) welding and electron-beam (EB) welding. It was consequently decided to pursue investigations on intermediate-sized blanks of 1.8 m diameter.

Two blanks were purchased, one from Linde (Germany, build-up welding) and one from Telas (France, electron-beam welding). The principles of both technologies are shown in Figures 1 and 2. Build-up welding consists in building up the complete aluminium piece by continuous deposition of a welding seam. After selection of the proper alloy and optimization of the welding parameters, excellent homogeneity of the crystalline structure and extremely low porosity could be achieved. Although this technique is well known with steel and applied to pieces in the 10-m dimension range (pressure vessels), it was surprisingly less known by most aluminium manufacturers. A picture of a 500-mm build-up aluminium mirror blank is shown in Figure 3. Electron-beam welding is a well-mastered welding technique which consists of fusing pre-assembled pieces by means of an electron gun of sufficient power. The technique is well mastered in industry and the demand for scaling the technology up to large diameters already exists (naval construction). The pieces to be assembled can be cast, forged or rolled. An appreciable advantage of EB welding is that no extra material is introduced which reduces the risk of inhomogeneity. For the manufacturing of an astronomical mirror the most interesting process is to weld forged segments, since forged aluminium pieces show excellent homogeneity and very low porosity. A picture of the 1.8-metre EB welded mirror blank shortly after welding of a radial joint is shown in Figure 4.

All problems encountered at the blank manufacturing stage could be efficiently

Figure 3: *Build-up welded aluminium blank of 500 mm.*

solved, and no limitation could be found in a possible extrapolation to 8 metres. Independently of the ESO activity, experiments in the 8-metre range are carried out in the framework of the Eureka-funded LAMA project (Large Active Mirrors for Astronomy, INNSE/TECNOL, Italy, with REOSC/ONERA, France, under TELAS management). Two 4-metre-long segments which will repre-

Figure 4: *1.8-m aluminium blank shortly after welding of a segment.*

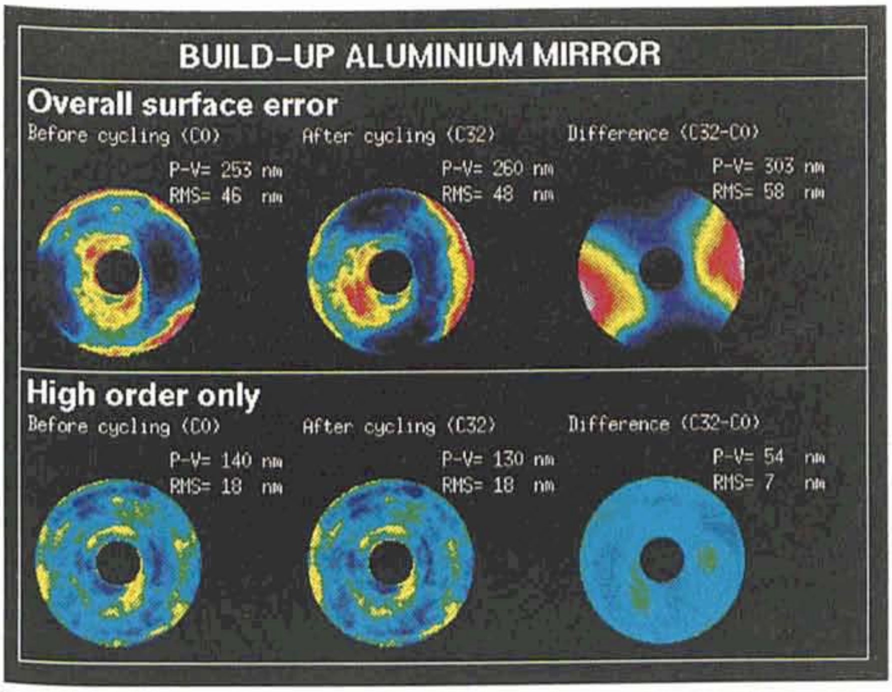


Figure 5: *Surface maps of the BU welded mirror before and after thermal cycles.*

sent 2/16 of an 8-metre mirror blank will be EB welded.

After manufacturing, the 1.8-metre blanks received thermal treatments which included annealing and cryogenic stabilization. After machining, the blanks were 1.8 metre in diameter, 300 mm thick, with a flat back and a f/1.67 spherical concave surface (within an accuracy already in the micron range, thanks to computer-controlled machining).

Both blanks were shipped to Reosc (France) for optical figuring. Rough grinding was followed by nickel coating, subcontracted by Reosc to Tecnol (Italy). Nickel coating consisted in the deposition of a nickel layer by a chemical process. The thickness of the layer is in the range of 0.1 mm. A nickel coating is required because aluminium is not directly polishable, at least within the same level of cosmetic quality as glass or nickel. After nickel coating the mirrors were fine ground and polished spherical, with a radius of curvature of 6 metre (f/1.67). Because of the innovative aspect of the experiment, ESO required that emphasis be put on the accuracy of surface measurements instead of the accuracy of the optical surface itself. However, both mirrors were polished well within specifications and according to Reosc, there would be no problem in achieving the same standards of quality as with glass. For what concerned bubbles and inclusions, both aluminium blanks were comparable to glass blanks. After polishing the effect of these bubbles and inclusions on the optical surface was totally negligible. The high expansion coefficient of the substrates did not cause significant problems, neither did the bimetallic effect between the aluminium and the nickel.

In polishing nickel coated aluminium mirrors, the danger is not with the adherence of the nickel layer but with the risk of breaking through the nickel coating, which required that the thickness of the coating be monitored. This risk emphasizes the requirements on accurate machining prior to coating, and on the uniformity of the nickel layer.

After acceptance of the mirrors, their stability towards ageing was checked. Thermal cycles followed by interferometric tests at centre of curvature were ordered from Reosc. One cycle consisted in varying the temperature from ambient temperature down to −20 degrees centigrade, then up to 40 degrees and back at ambient temperature, within about 24 hours. Both mirrors underwent 32 cycles, with intermediate checks after 4, 8, and 16 cycles.

The final results are summarized in Figures 5 and 6, which show the surface maps before and after 32 cycles. Surface errors were measured interferometrically at centre of curvature with a sampling of about 8000 points on the mirror (100 points across a diameter). The surface maps presented in Figures 5 and 6 result from the averaging of 50 interferograms each; the standard deviation is about 1 nanometre on the RMS surface error. Even on knife-edge images, no fine structure linked to the welding seams could be detected.

The most important figures are the variations of the surface errors rather than their absolute values, and above all the variation of high order effects, defined as surface errors after the 3rd and 5th order optical aberrations have been mathematically removed. While variations of the surface error function are observed, the global optical quality remains stable. The variation of the surface errors (axisymmetrical for the Telas mirror, astigmatic for the Linde) are less than one fringe and would be fully compensated by a simplified active support. They were detected after the first inter-

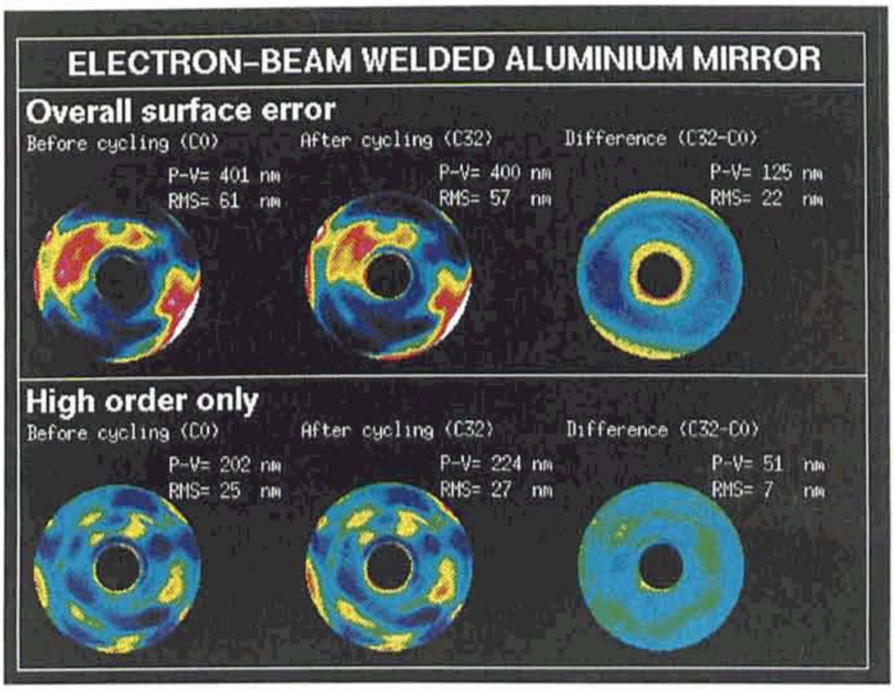


Figure 6: *Surface maps of the EB welded mirror before and after thermal cycles.*

mediate measurement (four cycles) and remained stable. High spatial frequency errors remained almost perfectly stable.

The conclusion is that in visible light (λ=500 nm) the stability of both mirrors towards ageing cycles is of the order of λ/25 for the overall rms surface errors and λ/70 for the high spatial frequency rms surface errors, a very positive result. Moreover, the changes occur during the first cycles and the surfaces remain almost perfectly stable afterwards. A question still open is the homogeneity of the coefficient of thermal expansion (CTE). Although the effect of possible inhomogeneities in the range of 1 to 5% of the nominal CTE (a very generous tolerance) could probably be compensated with active optics (unless they are very localized), a definite answer should preferably result from a series of tests at different temperatures.

This experiment has brought great confidence in the aluminium mirror technology. Both technologies, BU and EB welding, proved adequate for the manufacturing of 2-metre-class astronomical mirrors. Not only were the optical tests very successful, even more important is the fact that extrapolation to larger diameters now seems possible.

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